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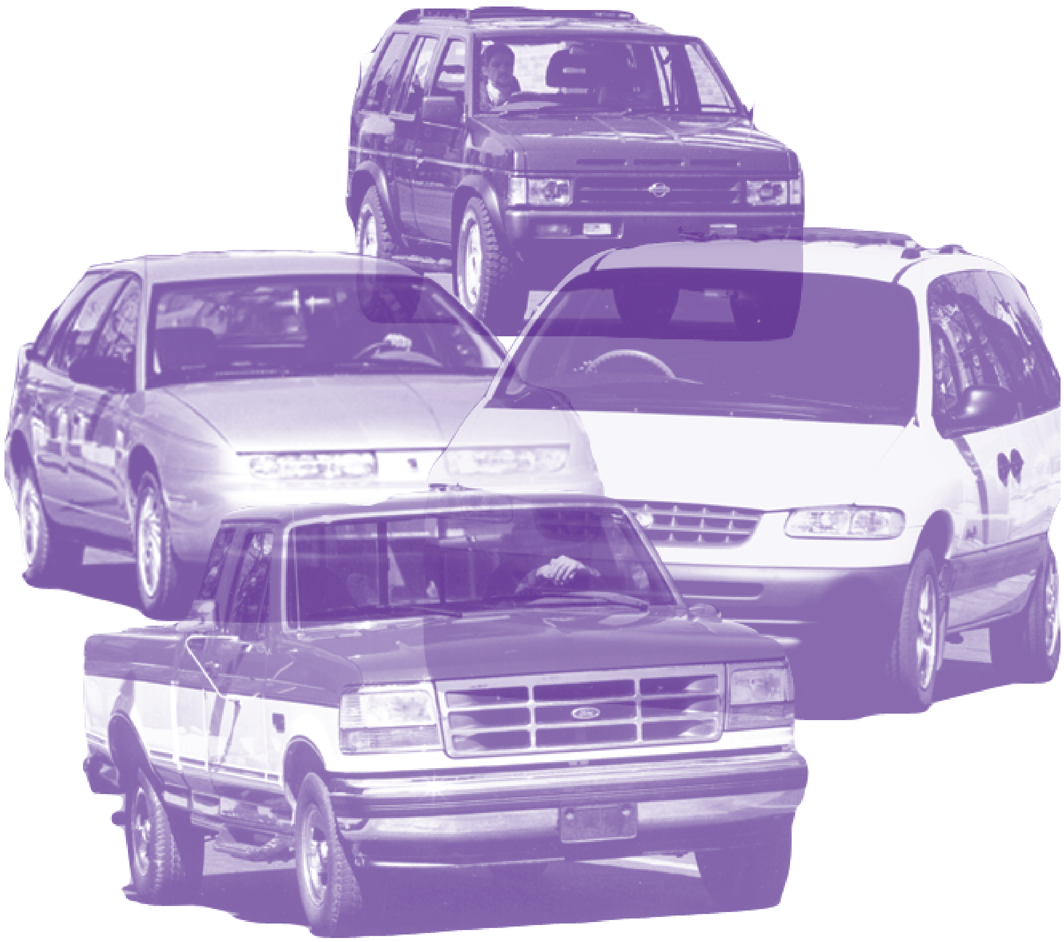
Light-Duty Automotive Technology and Fuel Economy Trends 1975 Through 2000



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Executive Summary

Introduction

This report summarizes key fuel economy and technology usage trends related to model year 1975 through 2000 light vehicles sold in the United States. Light vehicles include those vehicles that EPA and the U.S. Department of Transportation (DOT) classify as cars or light-duty trucks (sport utility vehicles, vans, and pickup trucks with less than 8,500 pounds gross vehicle weight ratings). The report finds that since 1988 average new light vehicle fuel economy has declined 1.9 miles per gallon (mpg), i.e., more than seven percent, primarily because light truck market share has increased and because fuel economy has been traded off for increased vehicle weight and performance.

The fuel economy values in this report are laboratory data and are significantly higher than the real world estimates used on new vehicle labels and in the *Fuel Economy Guide*. The fuel economy values in this report are similar to those used by the DOT for compliance with fuel economy standards, but because the values in this report exclude correction factors for alternative fuel capability and test procedure adjustments, they are always lower than those reported by DOT.

Importance of Fuel Economy

Since the early 1970s, EPA has issued reports that summarize new light vehicle fuel economy data. Fuel economy continues to be a major area of public and policy interest for several reasons, including:

(1) Fuel economy is directly related to carbon dioxide emissions, the most prevalent pollutant associated with global warming. Light vehicles contribute about 20% of all U.S. carbon dioxide emissions.

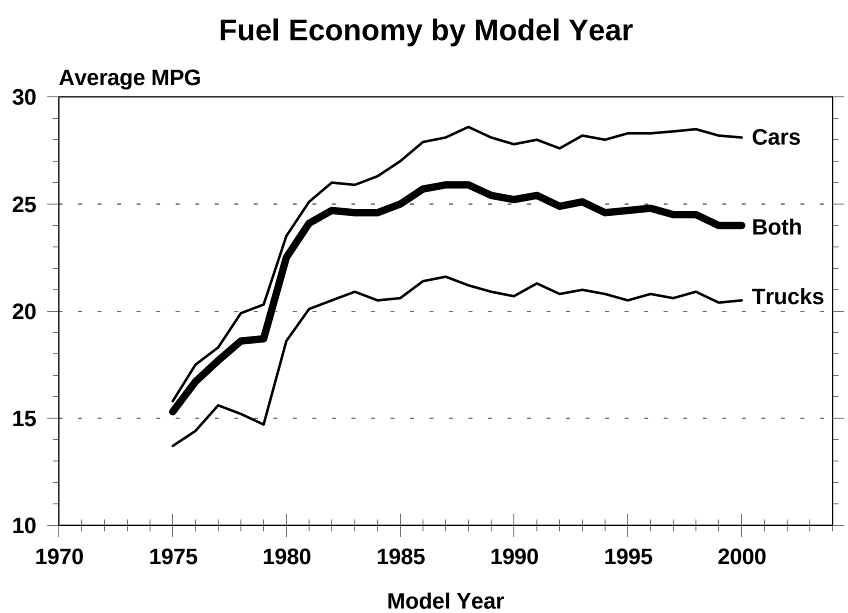
(2) Light vehicles account for approximately 40% of all U.S. oil consumption. Crude oil, from which nearly all light vehicle fuels are made, is considered to be a finite natural resource.

(3) Fuel economy is directly related to the cost of fueling a vehicle and is of greater interest when oil and gasoline prices rise, as has happened recently.

Highlight #1: Fuel Economy Remains at a 20 Year Low

There has been an overall declining trend in light vehicle fuel economy since 1988. The average fuel economy for all model year 2000 light vehicles is now 24.0 mpg, the same* as in 1999, and is as low as it has been at any time since 1980. This value is more than 1.9 mpg (about seven percent) lower than the peak value of 25.9 mpg achieved in 1987 and 1988. Within the light vehicle category for model year 2000, average fuel economy is 28.1 mpg for passenger cars and 20.5 mpg for light trucks.

All of the fleet-wide improvement in new light vehicle fuel economy occurred from the middle 1970s through the late 1980s, but it has been consistently falling since then. Viewed separately, the average fuel economy for new cars has been essentially flat over the last 15 years, varying only from 27.6 mpg to 28.6 mpg. Similarly, the average fuel economy for new light trucks has been largely unchanged for the past 20 years, ranging from 20.1 mpg to 21.6 mpg. The increasing market share of light trucks, which have lower average fuel economy than cars, accounts for much of the decline in fuel economy of the overall new light vehicle fleet.



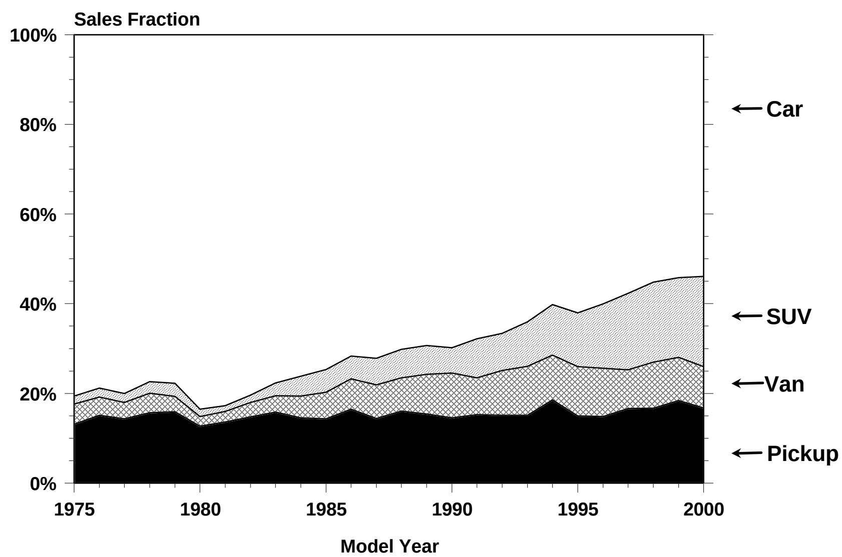
* Note the data for model years 1998 and 1999 in this report have been revised since the previous paper in this series was issued.

<u>Highlight #2:</u> <u>Trucks Represent Nearly Half of New Vehicle Sales</u>

Sales of light trucks, which include sport utility vehicles (SUVs), vans, and pickup trucks, have risen steadily for over 20 years and now make up 46% of the U.S. light vehicle market--more than twice their market share as recently as 1983.

Growth in the light truck market has been led recently by the explosive popularity of SUVs. SUV sales have increased by more than a factor of ten from less than 190,000 in 1975 (less than 2% of the overall new light vehicle market) to over 3.2 million in 2000 (20% of the market). Over the same period, the market share for vans doubled from 4.5 to 9%, and for pickup trucks, grew from 13 to 17%. Between 1975 and 2000, market share for new passenger cars and wagons decreased from 81 to 54%. EPA estimates that the new light trucks sold in 2000 will consume, over their lifetimes, about 56% of the fuel used by all of the new light vehicles sold in 2000. For model year 2000, cars average 28.1 mpg, vans 22.5, pickups 20.1 and SUVs 20.0.

Sales Fraction by Vehicle Type

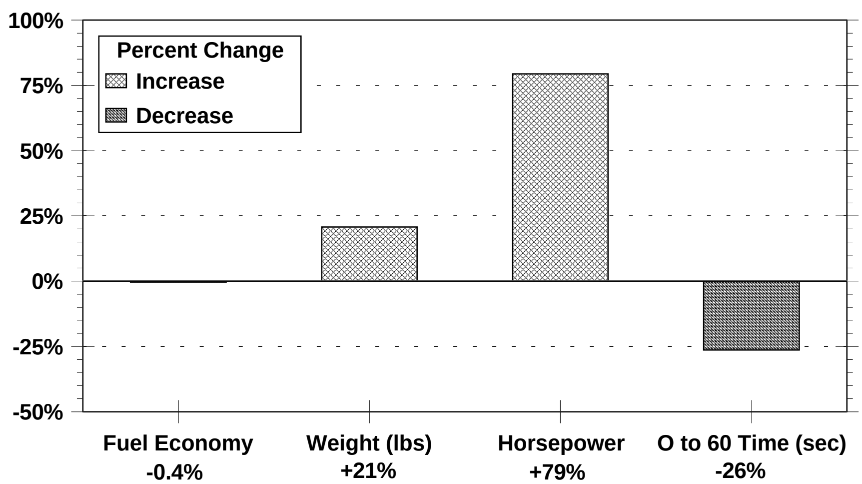


<u>Highlight #3</u>: <u>Fuel Economy is Being Traded for Weight and Power</u>

More efficient technologies continue to enter the new light vehicle fleet and are being used to increase light vehicle weight and acceleration rather than fuel economy. This year's light vehicles will have about the same average fuel economy as those built in model year 1981. Based on accepted engineering relationships, however, had the new 2000 light vehicle fleet had the same average weight and performance as in 1981, it could have achieved 25% higher fuel economy.

More efficient technologies-–such as engines with more valves and more sophisticated fuel injection systems, and transmissions with lockup torque convertors and extra gears–- continue to penetrate the new light vehicle fleet. The trend has clearly been to apply these new technologies to increase average new vehicle weight, power, and performance while maintaining fuel economy constant. This is reflected by heavier average vehicle weight (up 21% since 1981, up 1% since 1999), rising average horsepower (up 79% since 1981, up 3% since 1999), and lower 0 to 60 mile-per-hour acceleration time (26% faster since 1981, 2% faster since 1999).

Percent Change from 1981 to 2000
in Average Vehicle Characteristics



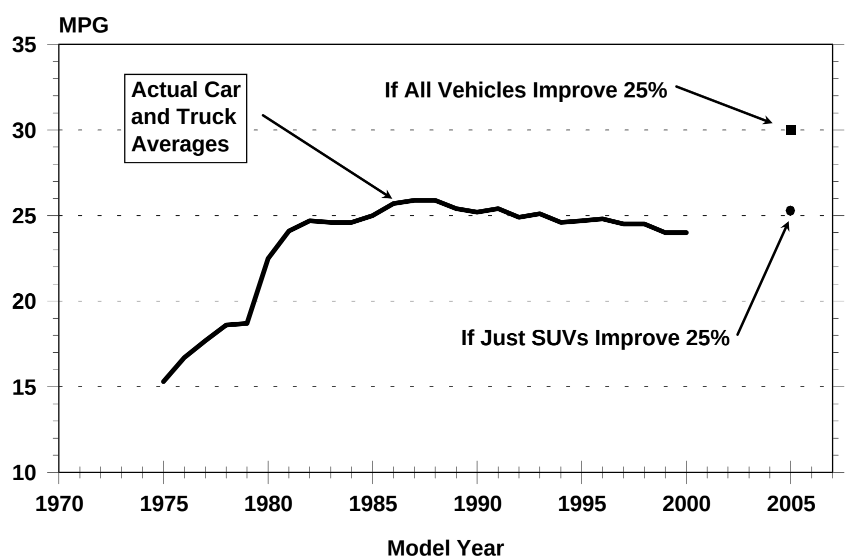
<u>Highlight #4</u>: <u>Ford and General Motors are Pledging to Increase Fuel Economy</u>

Ford Motor Company recently pledged to increase the fuel economy of its entire line of sport utility vehicle sales by 25 percent by the 2005 model year. General Motors pledged to remain the truck fuel economy leader. *If* all manufacturers were to voluntarily increase the average fuel economy of their *entire* light vehicle fleets by 25 percent by 2005, average new light vehicle fuel economy would increase from 24 mpg to 30 mpg.

Ford's pledge would result in an increase in the laboratory fuel economy of Ford's SUVs from about 18 mpg to about 23 mpg. General Motors, whose SUVs average around 19 mpg, pledged to remain the truck fuel economy leader.

If all manufacturers chose to match Ford's commitment to increase SUV fuel economy by 25 percent by 2005, then average SUV fuel economy would increase from 20.0 mpg to 25.0 mpg, and overall light vehicle fuel economy would increase from 24.0 mpg to 25.2 mpg. Further, if all manufacturers chose to voluntarily increase the average fuel economy of all of their light vehicles by 25 percent, then the average fleetwide fuel economy would rise from 24.0 mpg to 30.0 mpg.

Effect if Fuel Economy is Improved 25% by 2005



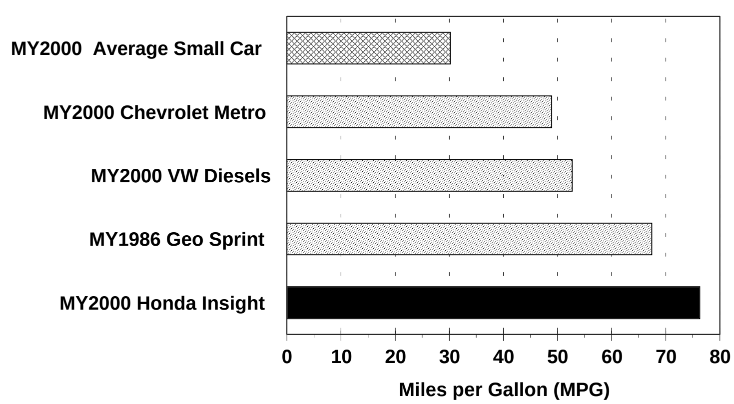
Highlight #5: The Honda Insight Hybrid is the Most Fuel Efficient U.S. Vehicle Since 1975

The model year 2000 Honda Insight two-seater is the most fuel efficient vehicle sold in the United States since 1975 and likely the most fuel efficient vehicle ever sold in the U.S. market.

A major development in model year 2000 was the introduction of a gasoline/battery hybrid vehicle. The Honda Insight is the first hybrid car ever sold in the U.S. market. It has a manual transmission and its drivetrain includes a gasoline-fueled engine, a battery used for traction, a regenerative braking system, and an electric motor/generator. The two-seater Insight has a laboratory fuel economy rating of 76.3 mpg, and *Fuel Economy Guide/*label ratings of 61 mpg city and 70 mpg highway.

The Insight's laboratory fuel economy value is about 9 mpg higher than the second most fuel efficient vehicle sold in the United States since 1975, a 1986 Geo Sprint mini-compact. The Insight's fuel economy is also about 25 mpg higher than that for the next most efficient model year 2000 vehicles, the Volkswagen Beetle/Golf/Jetta diesels and a gasoline-powered Chevrolet Metro. Like the Insight, all of these values are for models equipped with manual transmissions. The introduction of the Insight may be the start of a trend towards increasing use of hybrid vehicle technology. For model year 2001, Toyota is introducing in the U.S. market a hybrid vehicle, the Prius. This compact car has a laboratory fuel economy rating of 57.6 mpg, and *Fuel Economy Guide/*label ratings of 52 mpg city and 45 mpg highway.

Comparison of the Honda Insight with Other High Fuel Economy Vehicles



I. Introduction

Light-duty automotive technology and fuel economy trends are examined herein, as in preceding papers in this series [1-27], using the latest and most complete EPA data available. The source database was frozen in January 2000.

Through model year 1998, the fuel economy and vehicle sales data used for this report were obtained from the most complete databases used for corporate average fuel economy standards and "gas guzzler" compliance purposes. For all practical purposes, these databases are stable and are not expected to change in the future. For model years 1999 and 2000, the fuel economy and sales data used for this report were extracted from the database used for the federal government's fuel economy public information programs: the *Fuel Economy Guide* and the mpg labels that are placed on new vehicles. The vehicle sales data for 1999 and 2000 used for this report have been adjusted, as necessary, to take into account sales data available in trade publications at the time the database was frozen.

The mpg data in this series of reports are unadjusted laboratory data, with no correction for laboratory to on-road shortfall, alternative fuels capability "credits", or test procedure adjustment. Accordingly, the mpg values in this report are always slightly lower than those reported by the Department of Transportation and significantly higher than those provided in the *Fuel Economy Guide*. The laboratory fuel economy values are adjusted downward (the city value by 10 percent and the highway value by 22 percent) to obtain the real world projections used on new vehicle labels and in the *Fuel Economy Guide*. These systematic differences do not influence the fuel economy and technology trends in this report.

Where only one mpg value is presented in this report, it is the "composite 55/45 combined mpg", i.e.,

$$MPG_{55/45} = 1 / (.55/ MPG_C + .45/MPG_H)$$

where MPG_C is the fuel economy on the EPA City Driving cycle and MPG_H is the fuel economy on the EPA Highway Driving cycle.

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* Numbers in brackets denote references listed at the end of the text.

All vehicle weight data are based on inertia weight class (nominally curb weight plus 300 pounds). For vehicles with inertia weights up to and including the 3000-pound inertia weight class, these classes have 250-pound increments. For vehicles above the 3000-pound inertia weight class (i.e., vehicles 3500 pounds and above), 500-pound increments are used. All interior volume data for cars built after model year 1977 are based on the metric used to classify cars for the DOE/EPA *Fuel Economy Guide*. The car interior volume data in this paper combine that of the passenger compartment and trunk/cargo space. In the *Fuel Economy Guide*, interior volume is undefined for the two-seater class; for this series of reports, all two-seater cars have been assigned an interior volume value of 50 cubic feet.

The light truck data used in this series of papers includes only vehicles classified as light trucks with gross vehicle weight ratings (GVWR) up to 8,500 pounds. Vehicles with GVWR between 8,500 and 10,000 pounds are not included in the database used for this report. Omitting these vehicles influences the overall averages for all variables studied in this paper. Currently, total sales of trucks with GVWR between 8,500 and 10,000 pounds represent only about 6 or 7% of the total sales of trucks with GVWR of 8,500 pounds or less.

To the extent that trucks with GVWR between 8,500 and 10,000 pounds have lower fuel economy than the average for the trucks reported in this paper, the average fuel economy of the 0 to 10,000 pound GVWR fleet will be lower (and the fuel consumption higher) than the values reported here. For example, based on an examination of final sales data from trade publications and analysis of fuel economy data from a limited number of laboratory tests of recent (i.e., 1997 to 2000) model years, model year 1998 trucks with GVWR of 8,500 to 10,000 pounds have an estimated average fuel economy of approximately 12.7 mpg.

Combining the 12.7 mpg value for trucks above 8,500 GVWR with that for model year 1998 trucks with GVWR below 8,500 (i.e., 20.9 mpg) results in an average fuel economy of 20.1 mpg, or about 4% lower than the light-truck average for 1998 shown in this paper. Similarly, the average fuel economy for cars and all trucks under 10,000 GVWR for that year would have been 23.7 mpg, compared to a value of 24.5 mpg obtained when the heavier trucks are excluded. Note that model year 1998 was selected for this example because it was the most current year for which final sales data were available when the source data base used for this report was frozen.

In addition to mpg, some tables in this paper contain alternate measures of vehicle fuel efficiency as used in reference 17. “Ton-mpg” is defined as a vehicle’s mpg multiplied by its inertia weight in tons. This metric provides an indication of a vehicle’s ability to move weight (i.e., its own plus a nominal payload). Ton-mpg is a measure of powertrain/drive-line efficiency. Just as an increase in vehicle mpg at constant weight can be considered an improvement in a vehicle’s efficiency, an increase in a vehicle’s weight-carrying capacity at constant mpg can also be considered an “improvement.”

“Cubic-feet-mpg” for cars is defined in this paper as the product of a car’s mpg and its interior volume, including trunk space. This metric associates a relative measure of a vehicle’s ability to transport both passengers and their cargo. An increase in vehicle volume at constant mpg could be considered an improvement just as an increase in mpg at constant volume can be.

“Cubic-feet-ton-mpg” is defined in this paper as a combination of the two previous metrics, i.e., a car’s mpg multiplied by its weight in tons and also by its interior volume. It ascribes vehicle utility to the ability to move both weight and volume.

This paper also includes an estimate of 0-to-60 MPH acceleration time, calculated from engine rated horsepower and vehicle inertia weight, from the relationship:

$$t = F\ (HP/WT)^{-f}$$

where the values used for F and f coefficients are .892 and .805 respectively for vehicles with automatic transmissions and .967 and .775 respectively for those with manual transmissions [28]. Other authors [29, 30, and 31] have evaluated the relationships between weight, horsepower, and 0-to-60 acceleration time and have calculated and published slightly different values for the F and f coefficients.

The 0-to-60 estimate used in this paper is intended to provide a quantitative time "index" of vehicle performance capability. It is the authors’ engineering judgment that, given the differences in test methods for measuring 0-to-60 time and given the fact that the weight is based on inertia weight, use of these other published values for the F and f coefficients would not result in a significantly different 0-to-60 relative performance estimate. The results of a similar calculation of estimated “top speed” are also included in some tables.

For cars, vehicle classification as to vehicle type, size class, and manufacturer/origin generally follows fuel economy label, *Fuel Economy Guide*, and fuel economy standards protocols; exceptions are listed in Appendix A. In many of the passenger car tables, large sedans and wagons are aggregated as "Large," midsize sedans and wagons are aggregated as "Midsize," and "Small" includes all other cars. In some of the car tables, an alternative classification system is used, namely: Large Cars, Large Wagons, Midsize Cars, Midsize Wagons, Small Cars, and Small Wagons with the EPA “Two-Seater, Mini-Compact, Subcompact, and Compact” car classes combined into the “Small Car” class.

The truck classification scheme used for all model years in this paper is slightly different from that used prior to 1999 in this series, because pickups, vans, and sports utility vehicles (SUVs) are sometimes each subdivided as "Small," “Midsize,” and "Large." These truck size classifications are based primarily on published wheelbase data according to the following criteria:

	Pickup	Van	SUV
Small	Less than 105"	Less than 109"	Less than 100"
Midsize	105" to 115"	109" to 124"	100" to 110"
Large	More than 115"	More than 124"	More than 110"

This classification scheme is similar to that used in many trade and consumer publications. For those vehicle nameplates with a variety of wheelbases, the size classification was determined by considering only the smallest wheelbase produced. Grouping all vehicles into classes and then constructing time trends of parameters of interest, like mpg, can provide interesting and useful results. The results, however, are a strong function of the class definitions. Nowhere is this more important than in the definition of “Domestic” and “Import” truck or “Domestic,” “European,” and “Asian” car used in this series of papers.

Classification of a vehicle as a “Domestic” or “Import” truck, or “Domestic,” “European Import,” or “Asian Import” car is based on the authors’ engineering judgment of where the majority of the vehicle’s powertrain and emissions control system development and certification work was done. It is meant to be a tracking system for technical parameters related primarily to engine and transmission development and is not intended to be a replacement for other domestic/import definitions such as those used for fuel economy or tariff compliance programs. Classes based on other definitions are possible, and results from these other classifications may also be useful.

Appendix B lists the model year 2000 nameplates by size class and their sales-weighted average 55/45 mpg as of the data freeze date. Appendix C lists and describes the most, and least, fuel efficient vehicles for model years 1975 to 2000.

Appendixes D through G contain a series of tables in which the fleet is grouped into classes and stratified based on vehicle type, vehicle type and size, EPA car class, and inertia weight class respectively.

Appendixes H, I, and J contain a series of tables in which the fleet is grouped into classes and stratified based on transmission type and number of gears, cylinder count, and by the number of engine valves per cylinder, respectively.

Appendix J contains information about the fleet grouped into market segment classes which reflect Domestic, European, and Asian design sources for cars and Domestic and Imported design sources for trucks.

Appendix L contains tables that provide detailed data related to the Fuel Economy Improvement Potential section of this report.

II. General Car and Truck Trends

Table 1 gives sales and fuel economy of passenger cars, light trucks, and all light-duty vehicles (cars and light trucks) for model years 1975 to 2000. As Figure 1 shows, for the past dozen years, the fuel economy of the combined car and light-truck fleet has gradually declined and remains about two mpg, or about 7%, below the peak value of 25.9 mpg attained in 1987 and 1988. Both car and light-truck mpg have been very stable during this period, since 1986 cars have been within 0.5 mpg of 28.1 and light trucks within 0.5 mpg of 21.1 since 1983.

For MY2000, average mpg of all cars and trucks combined is projected to be 24.0 or lower at any time since 1980 when the average was 22.5. The decline in the overall combined car/truck average is primarily due to the increasing market share of light trucks which have lower average fuel economy than cars. The increase in the light-truck share of the market is the most important trend in the light vehicle fleet over recent years and one which has yet to level off. Due to the increase in sales of vans and SUVs (see Figure 2), the estimated light-truck share of the market has now passed 46%, more than double what it was in

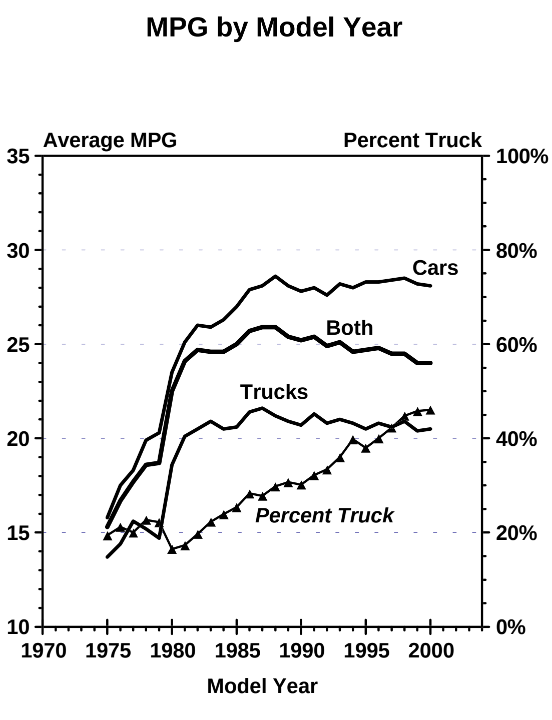

Figure 1

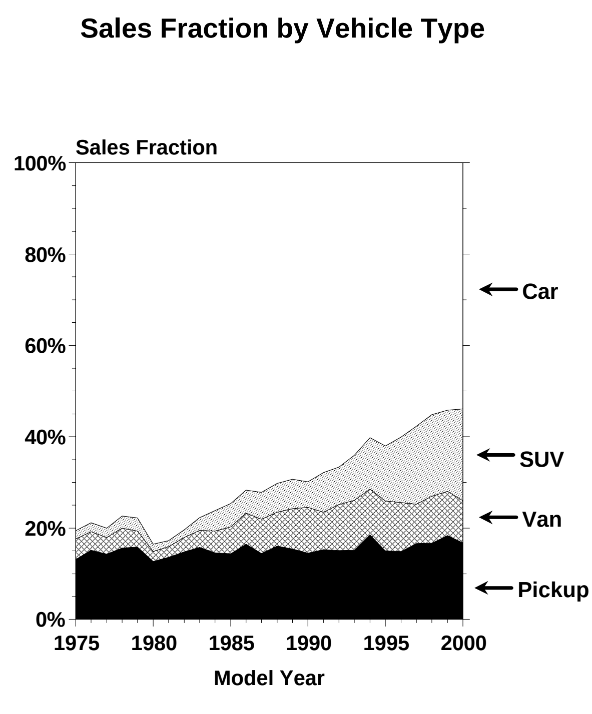

Figure 2

Table 1

Fuel Economy Characteristics of 1975 to 2000 Light-Duty Vehicles

MODEL YEAR	SALES (000)	FRAC	FUEL ECONOMY CITY	HWY	55/45	TON -MPG	CU-FT -MPG	CU-FT- TON-MPG
Cars								
1975	8237	.806	13.7	19.5	15.8	32.3		
1976	9722	.788	15.2	21.3	17.5	35.5		
1977	11300	.800	16.0	22.3	18.3	36.4	2091	4021
1978	11175	.773	17.2	24.5	19.9	35.9	2240	3926
1979	10794	.778	17.7	24.6	20.3	35.4	2258	3878
1980	9443	.835	20.3	29.0	23.5	36.6	2507	3841
1981	8733	.827	21.7	31.1	25.1	38.9	2744	4161
1982	7819	.803	22.3	32.7	26.0	40.1	2836	4273
1983	8002	.777	22.1	32.7	25.9	40.7	2904	4426
1984	10675	.761	22.4	33.3	26.3	41.1	2910	4425
1985	10791	.746	23.0	34.3	27.0	42.0	2990	4548
1986	11015	.717	23.7	35.5	27.9	42.6	3057	4585
1987	10731	.722	23.9	35.9	28.1	42.8	3051	4569
1988	10736	.702	24.2	36.6	28.6	43.7	3119	4693
1989	10018	.693	23.8	36.3	28.1	43.8	3080	4723
1990	8810	.698	23.4	36.0	27.8	44.2	3014	4746
1991	8524	.678	23.6	36.3	28.0	44.3	3040	4746
1992	8108	.666	23.1	36.3	27.6	44.9	3040	4877
1993	8457	.640	23.6	37.0	28.2	45.4	3107	4930
1994	8414	.602	23.4	36.9	28.1	45.7	3086	4956
1995	9396	.620	23.6	37.6	28.3	46.4	3130	5045
1996	7890	.600	23.5	37.6	28.3	46.5	3124	5077
1997	8335	.577	23.7	37.7	28.4	46.7	3127	5076
1998	7968	.552	23.7	37.9	28.5	47.3	3138	5146
1999	8608	.542	23.4	37.4	28.2	47.6	3119	5208
2000	8633	.539	23.3	37.4	28.1	47.7	3123	5252
Trucks								
1975	1987	.194	12.1	16.2	13.7	28.4		
1976	2612	.212	12.8	16.9	14.4	30.5		
1977	2823	.200	14.0	18.1	15.6	33.0		
1978	3273	.227	13.8	17.5	15.2	32.4		
1979	3088	.222	13.4	16.8	14.7	32.1		
1980	1863	.165	16.5	21.9	18.6	36.3		
1981	1821	.173	17.8	23.9	20.1	38.8		
1982	1914	.197	18.1	24.4	20.5	39.7		
1983	2300	.223	18.3	25.2	20.9	39.9		
1984	3345	.239	17.9	24.8	20.5	39.3		
1985	3669	.254	18.0	24.9	20.6	39.6		
1986	4350	.283	18.8	25.9	21.4	40.4		
1987	4134	.278	18.8	26.5	21.6	40.5		
1988	4559	.298	18.3	26.2	21.2	40.9		
1989	4435	.307	18.1	25.8	20.9	41.2		
1990	3805	.302	17.8	25.9	20.7	41.8		
1991	4049	.322	18.3	26.6	21.3	42.2		
1992	4064	.334	17.8	26.2	20.8	42.4		
1993	4754	.360	17.9	26.5	21.0	42.9		
1994	5572	.398	17.8	26.1	20.8	43.1		
1995	5749	.380	17.5	25.9	20.5	43.2		
1996	5254	.400	17.7	26.5	20.8	44.3		
1997	6108	.423	17.6	26.1	20.6	44.9		
1998	6477	.448	17.7	26.6	20.9	44.9		
1999	7276	.458	17.4	25.9	20.4	44.7		
2000	7381	.461	17.5	26.0	20.5	45.5		

Table 1 (Continued)

Fuel Economy Characteristics of 1975 to 2000 Light-Duty Vehicles

MODEL YEAR	SALES (000)	FRAC	FUEL ECONOMY CITY	HWY	55/45	TON -MPG
Both Cars and Trucks						
1975	10224	1.000	13.4	18.7	15.3	31.6
1976	12334	1.000	14.6	20.2	16.7	34.4
1977	14123	1.000	15.6	21.3	17.7	35.7
1978	14448	1.000	16.3	22.5	18.6	35.1
1979	13882	1.000	16.5	22.3	18.7	34.7
1980	11306	1.000	19.6	27.5	22.5	36.6
1981	10554	1.000	20.9	29.5	24.1	38.9
1982	9732	1.000	21.3	30.7	24.7	40.0
1983	10302	1.000	21.2	30.6	24.6	40.5
1984	14020	1.000	21.2	30.8	24.6	40.7
1985	14460	1.000	21.5	31.3	25.0	41.4
1986	15365	1.000	22.1	32.2	25.7	42.0
1987	14865	1.000	22.2	32.6	25.9	42.1
1988	15295	1.000	22.1	32.7	25.9	42.9
1989	14453	1.000	21.7	32.3	25.4	43.0
1990	12615	1.000	21.4	32.2	25.2	43.5
1991	12573	1.000	21.6	32.5	25.4	43.6
1992	12172	1.000	21.0	32.1	24.9	44.1
1993	13211	1.000	21.2	32.4	25.1	44.5
1994	13986	1.000	20.8	31.7	24.6	44.7
1995	15145	1.000	20.8	32.1	24.7	45.2
1996	13144	1.000	20.8	32.2	24.8	45.6
1997	14442	1.000	20.6	31.8	24.5	45.9
1998	14445	1.000	20.6	31.9	24.5	46.3
1999	15884	1.000	20.3	31.1	24.0	46.3
2000	16015	1.000	20.2	31.1	24.0	46.7

Estimated Vehicle Lifetime Fuel Consumption Share

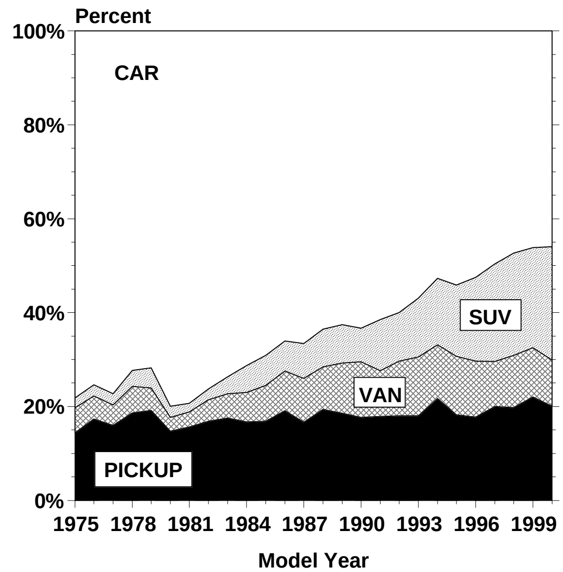

Figure 3

any year between 1975 and 1983. Vans and SUVs combined account for nearly 30% of this year’s fleet, compared to about 6% in 1975.

The trends in market share, fuel economy, and estimate of vehicle lifetime travel can be combined to estimate the fraction of all light-vehicle fuel consumption that can be attributed to the four major vehicle types, namely pickup trucks, vans, SUVs, and cars. The values plotted in Figure 3 represent the fuel-consumption fraction, by model year and type of vehicle.

Considering the fuel used by both passenger cars and light trucks as 100%, Figure 3 shows that, on a model year basis, the estimated share of the vehicle lifetime fuel consumed by light trucks has exceeded 50% for the past several model years. Note that this calculation uses the same useful life values that EPA

Table 2 **Sales-Weighted Percentile Distribution of Car Mpg**

Model Year	0%	1%	5%	10%	20%	25%	50%	75%	80%	90%	95%	99%	100%	Actual Average
	<<----------					Percentile Level							---------->>	
1975	9.8	10.6	11.5	11.9	12.9	13.1	15.4	19.7	21.0	24.6	27.3	32.1	33.2	15.8
1976	10.1	12.2	13.2	13.7	14.5	14.9	17.1	20.3	22.1	26.9	29.0	33.2	35.8	17.5
1977	9.7	12.4	13.6	14.5	15.9	16.4	17.7	20.3	22.1	28.4	32.9	39.8	44.3	18.3
1978	9.4	13.1	14.7	15.5	16.6	17.5	19.9	23.2	25.0	29.3	33.1	38.5	44.1	19.9
1979	9.2	14.0	15.4	16.1	17.2	17.7	19.9	24.0	25.7	29.1	31.2	36.4	46.0	20.3
1980	9.2	16.3	17.3	18.6	20.2	20.6	23.2	27.2	28.3	31.4	34.2	42.4	47.4	23.5
1981	5.0	17.1	18.5	19.9	21.5	21.9	25.3	29.8	30.8	33.8	36.9	44.5	48.1	25.1
1982	9.9	18.0	19.3	19.9	21.4	22.4	27.5	30.5	31.9	34.7	38.3	45.2	50.3	26.0
1983	9.9	19.1	19.4	19.9	21.0	21.6	26.1	31.5	33.1	36.7	39.0	43.1	53.3	25.9
1984	9.9	19.4	19.9	20.2	21.1	22.7	26.9	31.1	32.1	35.1	38.5	44.9	56.5	26.3
1985	9.9	20.6	20.8	21.5	22.8	23.2	27.1	31.4	32.6	35.1	39.3	45.9	58.5	27.0
1986	8.7	21.5	22.0	22.9	23.9	24.2	28.9	31.4	32.9	35.6	39.6	46.6	67.4	27.9
1987	8.7	21.5	21.8	22.5	24.6	25.0	28.3	32.1	32.9	35.8	37.4	45.6	65.6	28.1
1988	8.7	21.4	22.6	22.9	25.1	26.5	28.9	32.3	33.0	36.3	38.7	45.6	65.6	28.6
1989	8.7	22.2	22.8	23.1	24.7	25.8	27.8	31.4	32.4	34.9	37.3	45.4	61.2	28.1
1990	10.9	21.5	22.5	23.0	25.3	25.3	27.7	31.0	31.4	34.0	37.1	41.9	65.3	27.8
1991	10.0	21.7	23.0	23.5	25.0	25.3	27.8	31.4	32.0	35.3	38.0	44.3	65.3	28.0
1992	10.0	21.6	22.7	23.5	24.6	24.7	27.0	30.7	31.4	34.7	38.2	48.1	65.3	27.6
1993	10.0	21.5	22.9	23.8	25.5	25.6	27.8	31.6	33.1	35.2	38.6	44.1	65.3	28.2
1994	12.9	21.7	22.9	23.5	24.8	25.6	27.6	31.3	32.8	34.5	37.1	44.2	65.8	28.1
1995	10.3	22.1	22.8	23.3	25.8	26.0	27.8	31.7	32.8	35.8	38.6	42.2	59.2	28.3
1996	12.0	22.8	23.2	23.7	25.6	25.8	27.4	31.5	32.4	35.8	38.3	42.2	54.8	28.3
1997	12.7	22.6	23.2	24.0	25.4	25.6	28.1	31.6	32.6	35.4	37.1	41.7	54.4	28.4
1998	12.8	22.7	23.1	24.4	25.7	25.9	27.8	31.0	32.6	36.3	37.0	39.4	53.6	28.5
1999	12.5	20.5	22.7	24.2	25.5	26.3	27.7	30.5	31.2	35.4	36.7	39.5	52.6	28.2
2000	11.7	21.4	23.4	24.1	26.0	26.3	27.5	30.1	31.3	34.9	37.2	39.6	76.3	28.1
Change Since 1975	1.9	10.8	11.9	12.2	13.1	13.2	12.1	10.4	10.3	10.3	9.9	7.5	43.1	12.3
Percent Change	19%	102%	103%	103%	102%	101%	79%	53%	49%	42%	36%	23%	130%	78%

considers for the Tier 2 Motor Vehicle Emissions Standards, namely 120,000 miles for both cars and trucks. The calculation also assumes that the relative city and highway driving fractions are the same for all vehicle types.

The data in most tables and figures in this report are a time series of sales-weighted averages of a substantial number of individual data points. For any given model year, there is also some interest in the within-year distribution of the data. Tables 2 and 3 show the mpg distribution data for cars and light trucks. In Figures 4 and 5, for each model year, the sales-weighted mpg's at several percentile levels are shown as lines connecting the vehicles with the lowest fuel economy each year, the worst and best one percent of vehicles; and at the 25 and 75 percentile level with the area between the 25 and 75 percentile level representing half of the cars and trucks built each year. Percentile lines having constant slope represent percentiles

Table 3 **Sales-Weighted Percentile Distribution of Truck Mpg**

Model Year	0%	1%	5%	10%	20%	25%	50%	75%	80%	90%	95%	99%	100%	Actual Average
1975	9.0	9.2	10.5	10.8	11.3	11.5	13.8	15.7	18.1	21.0	22.2	22.5	24.3	13.7
1976	9.1	10.6	11.4	11.7	12.3	12.3	13.9	16.6	18.4	20.2	23.0	25.3	27.0	14.4
1977	9.4	10.5	12.1	12.7	13.6	13.7	14.8	18.2	18.6	23.0	25.4	28.4	32.2	15.6
1978	9.5	11.2	12.2	12.5	13.0	13.1	14.4	18.5	19.2	23.0	26.1	28.6	32.7	15.2
1979	9.4	9.6	10.8	11.2	12.1	12.7	14.4	18.2	18.9	22.6	24.3	29.7	30.5	14.7
1980	9.9	12.5	13.4	14.2	15.5	15.8	19.0	22.7	23.9	26.0	27.2	30.3	45.0	18.6
1981	11.1	13.2	14.7	15.7	17.4	17.9	19.0	23.9	25.3	29.4	31.2	36.8	42.3	20.1
1982	11.9	13.1	14.3	15.6	17.4	17.8	20.1	24.6	26.7	28.5	31.0	36.0	43.7	20.5
1983	12.1	13.1	14.2	15.9	17.5	18.1	21.4	25.7	26.8	29.4	31.0	35.5	45.1	20.9
1984	11.2	13.0	14.2	15.4	17.3	17.7	21.5	24.2	25.3	28.4	30.5	34.5	42.6	20.5
1985	11.3	13.4	14.6	16.1	16.5	17.4	21.9	24.5	25.4	27.9	29.3	33.6	42.6	20.6
1986	12.2	13.9	15.9	17.0	17.8	18.5	21.8	25.7	27.0	28.1	30.0	32.9	42.6	21.4
1987	11.8	13.8	16.3	16.9	17.8	19.0	21.8	25.2	26.8	28.1	30.6	33.1	42.8	21.6
1988	11.7	14.5	16.4	16.9	18.3	18.4	22.0	24.0	25.6	27.7	29.6	33.3	33.3	21.2
1989	12.2	13.8	16.4	17.1	18.0	18.3	22.0	23.8	24.2	27.0	28.9	29.6	33.4	20.9
1990	11.9	13.9	16.0	16.7	17.8	18.5	21.1	22.9	24.4	26.8	28.9	29.3	33.5	20.7
1991	12.4	14.7	16.5	17.2	18.8	19.4	21.8	23.5	24.1	27.5	28.9	30.1	33.5	21.3
1992	12.4	14.9	16.7	17.1	18.2	18.9	21.0	23.4	24.1	26.7	28.2	29.8	33.5	20.8
1993	12.5	15.4	16.7	17.3	18.4	19.0	21.3	23.3	23.8	26.3	28.7	29.8	33.5	21.0
1994	14.7	15.7	16.6	17.0	18.0	18.5	20.7	23.6	23.8	27.5	28.4	29.5	33.5	20.8
1995	14.7	15.6	16.6	16.8	18.0	18.3	20.4	23.0	23.3	26.3	28.6	29.4	33.6	20.5
1996	14.7	14.7	16.7	17.4	17.9	18.4	21.1	23.3	23.7	26.8	27.6	29.8	31.3	20.8
1997	14.4	16.0	16.7	17.6	18.2	18.8	20.5	22.6	23.5	25.9	28.3	29.7	31.3	20.6
1998	14.5	15.8	16.5	17.2	18.1	18.7	21.1	23.6	24.1	26.8	27.9	29.5	30.8	20.9
1999	14.8	15.6	16.2	16.8	18.1	18.6	20.6	22.9	23.5	25.3	27.3	29.6	31.1	20.4
2000	15.0	15.5	16.2	17.2	18.5	18.7	20.5	22.6	23.4	25.0	27.3	29.6	31.1	20.5
Change Since 1975	6.0	6.3	5.7	6.4	7.2	7.2	6.7	6.9	5.3	4.0	5.1	7.1	6.8	6.8
Percent Change	67%	68%	54%	59%	64%	63%	49%	44%	29%	19%	23%	32%	28%	50%

where mpg has been constant with time, and lines having positive or negative slope represent percentiles where fuel economy is either improving or worsening with time.

On a percentage basis, for cars at the zero percentile, i.e., for those with the lowest fuel economy, there has been substantially less fuel economy improvement since 1975 than for those at the higher percentile levels shown in Table 1. The fuel economy of cars at the zero percentile level has improved only 1.9 mpg since 1975, compared to more than 10 mpg for all percentile levels up to the 90th percentile. In recent years, the cars with the lowest fuel economy have tended to be relatively high priced, low sales volume, performance-oriented Two Seaters. In contrast, the cars with the highest fuel economy each year have tended to be Subcompacts or Minicompacts with front-wheel drive, manual transmissions, and relatively high 0-to-60

Sales Weighted Car MPG Distribution

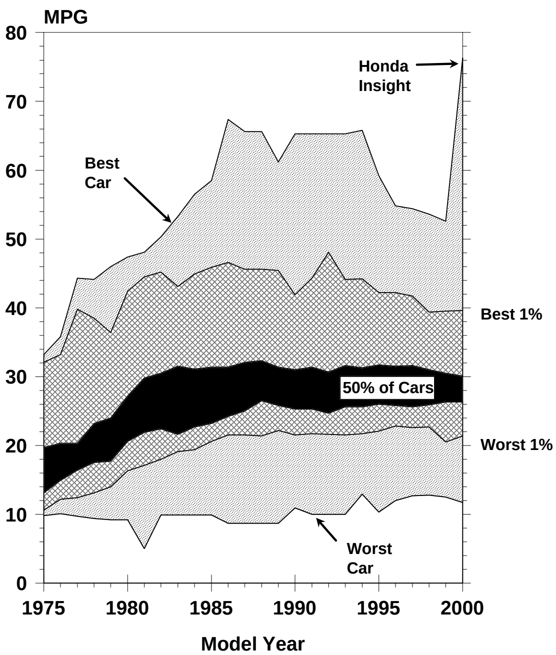

Figure 4

Sales Weighted Truck MPG Distribution

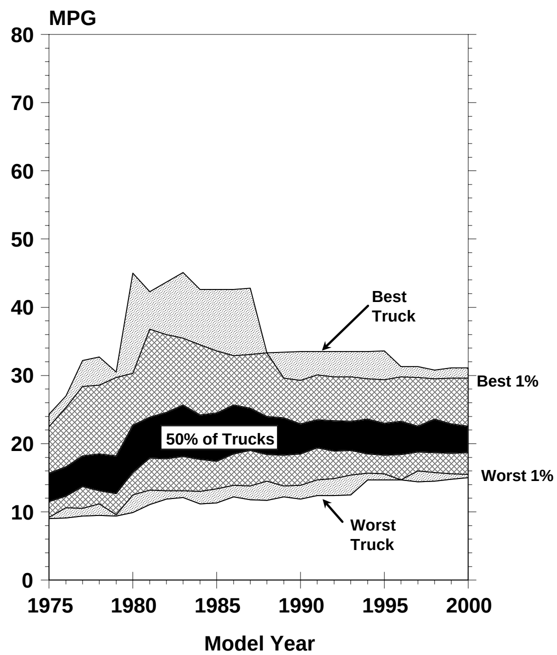

Figure 5

acceleration times. (See Appendix C for a listing and description of the cars and trucks with the highest and lowest fuel economy each year.)

The fuel economy difference between the least efficient and most efficient car increased from less than 25 mpg in 1975 to nearly 50 mpg a decade later in 1985 and is now, with the introduction for sale of the Honda Insight gasoline-electric hybrid vehicle, nearly 65 mpg. Despite this widening of the fuel economy range, half of the cars built each year remain within about 4 mpg of the actual model-year average. The Honda Insight, however, foreshadows what could happen if hybrid vehicles become widely accepted by the general public.

The overall mpg distribution trend for trucks is very similar to that for cars, except the fuel economy of the least efficient truck has increased by about 6 mpg since 1975, and there is a peak in the efficiency of the most efficient truck in the early 1980's when small pickup trucks with diesel engines were being sold. As a result, the fuel economy range between the most efficient and least efficient truck has narrowed from about 33 mpg in 1983 to about 16 mpg this year. Half of the trucks built each year since 1991 have been within about 4 mpg of each year’s average fuel economy value.

Table 4 gives vehicle size and design characteristics of light-duty vehicles. Average interior volume of cars has changed very little since 1977, decreasing from a maximum 110 cubic feet that year to a minimum of 104 cubic feet in 1980. Since 1992, interior volume for cars has averaged either 108 or 109 cubic feet. Between 1975 and 1984 (see Figure 6), average inertia weight for cars decreased nearly a thousand pounds; vehicle performance, as measured by estimated 0-to-60 time, was relatively constant; and average mpg increased from 15.8 to 26.3.

For the next five years, passenger car inertia weight remained relatively constant; 0-to-60 time decreased by about a second; and fuel economy reached a peak of 28.6 mpg in 1988, then dropped to 28.1 the next year. With three minor exceptions, passenger car inertia weight has increased every year since 1987 and is now more than 350 pounds higher than it was then. Similarly, estimated 0-to-60 time has decreased nearly every year and is now more than four seconds less than it was in 1981.

Table 4

Vehicle Size and Design Characteristics of 1975 to 2000 Light-Duty Vehicles

	<----------- Measured Characteristics ------------>									<----------- Percent by ----------->					
MODEL YEAR	SALES (000)	FRAC	55/45 MPG	VOL CU-FT	WGHT LB	HP	0-60 TIME	TOP SPD	HP/ WT	VEHICLE SIZE SMALL	MID	LARGE	DESIGNED DOM	EUR	ASIA
Cars															
1975	8237	.806	15.8		4057	136	14.2	111	.0331	55.4	23.3	21.3	81.6	8.2	10.3
1976	9722	.788	17.5		4058	134	14.4	110	.0324	55.4	25.2	19.4	84.9	5.4	9.7
1977	11300	.800	18.3	110	3943	133	14.0	111	.0335	51.9	24.5	23.5	82.2	5.5	12.2
1978	11175	.773	19.9	109	3587	124	13.7	111	.0342	44.7	34.4	21.0	80.2	6.3	13.5
1979	10794	.778	20.3	108	3484	119	13.8	110	.0338	43.7	34.2	22.1	80.4	5.6	14.0
1980	9443	.835	23.5	104	3101	100	14.3	107	.0322	54.4	34.4	11.3	71.2	8.4	20.4
1981	8733	.827	25.1	106	3075	99	14.4	106	.0320	51.5	36.4	12.2	71.7	6.0	22.3
1982	7819	.803	26.0	106	3054	99	14.4	106	.0320	56.5	31.0	12.5	70.4	6.3	23.3
1983	8002	.777	25.9	108	3111	104	14.0	108	.0330	53.1	31.8	15.1	71.0	5.5	23.5
1984	10675	.761	26.3	107	3098	106	13.8	109	.0339	57.4	29.4	13.2	75.9	6.0	18.1
1985	10791	.746	27.0	108	3092	111	13.3	111	.0355	55.7	28.9	15.4	72.3	6.2	21.6
1986	11015	.717	27.9	107	3040	111	13.2	111	.0360	59.5	27.9	12.6	68.2	6.6	25.1
1987	10731	.722	28.1	106	3030	112	13.0	112	.0365	63.5	24.3	12.2	61.6	6.9	31.5
1988	10736	.702	28.6	107	3046	116	12.8	113	.0375	64.8	22.3	12.8	61.2	6.3	32.5
1989	10018	.693	28.1	107	3099	121	12.5	115	.0387	58.3	28.2	13.5	61.9	5.5	32.6
1990	8810	.698	27.8	107	3175	129	12.1	117	.0401	58.6	28.7	12.8	56.8	5.0	38.2
1991	8524	.678	28.0	106	3153	132	11.8	118	.0413	61.5	26.2	12.3	56.2	4.6	39.2
1992	8108	.666	27.6	108	3239	141	11.5	120	.0428	56.5	27.8	15.6	58.3	4.1	37.7
1993	8457	.640	28.2	108	3207	138	11.6	120	.0425	57.2	29.5	13.3	60.4	3.4	36.2
1994	8414	.602	28.1	108	3249	143	11.4	121	.0432	58.5	26.1	15.4	55.7	4.0	40.3
1995	9396	.620	28.3	108	3262	152	10.9	125	.0460	57.3	28.6	14.0	58.5	5.4	36.1
1996	7890	.600	28.3	108	3281	154	10.8	125	.0464	54.3	32.0	13.6	57.8	5.1	37.0
1997	8335	.577	28.4	108	3274	156	10.7	126	.0469	55.1	30.6	14.3	55.1	6.5	38.4
1998	7968	.552	28.5	108	3306	159	10.6	127	.0475	49.4	39.2	11.4	55.1	7.9	37.0
1999	8608	.542	28.2	109	3366	165	10.5	128	.0483	47.8	38.7	13.5	53.5	10.3	36.2
2000	8633	.539	28.1	109	3386	170	10.3	130	.0495	46.1	34.8	19.1	49.4	13.9	36.7

Table 4 (Continued)

Vehicle Size and Design Characteristics of 1975 to 2000 Light-Duty Vehicles

MODEL YEAR	SALES (000)	FRAC	55/45 MPG	WGHT LB	HP	0-60 TIME	TOP SPD	HP/ WT	VEHICLE SIZE SMALL	MID	LARGE	DESIGNED DOM	VEHICLE TYPE PICKUP	VAN	SUV
	<--------- Measured Characteristics --------->								<---------------- Percent by ---------------->						
Trucks															
1975	1987	.194	13.7	4072	142	13.6	114	.0349	10.9	24.2	64.9	88.7	67.6	23.0	9.4
1976	2612	.212	14.4	4154	141	13.8	113	.0340	9.0	20.3	70.7	90.9	71.5	19.2	9.3
1977	2823	.200	15.6	4135	147	13.3	115	.0356	11.1	20.3	68.5	88.5	71.8	18.2	10.0
1978	3273	.227	15.2	4151	146	13.4	114	.0351	10.9	22.7	66.3	89.1	69.3	19.1	11.6
1979	3088	.222	14.7	4251	138	14.3	111	.0325	15.2	19.5	65.3	84.7	71.5	15.5	13.0
1980	1863	.165	18.6	3868	121	14.5	108	.0313	28.4	17.6	54.0	69.4	77.2	13.0	9.8
1981	1821	.173	20.1	3805	119	14.6	108	.0311	23.2	19.1	57.7	72.0	79.1	13.5	7.5
1982	1914	.197	20.5	3805	120	14.5	109	.0317	21.1	31.0	47.9	76.3	75.3	16.2	8.5
1983	2300	.223	20.9	3763	118	14.5	108	.0313	16.6	45.9	37.6	78.5	70.8	16.6	12.5
1984	3345	.239	20.5	3782	118	14.7	108	.0310	19.5	46.4	34.1	77.6	61.1	20.2	18.7
1985	3669	.254	20.6	3795	124	14.1	110	.0326	19.2	48.5	32.3	80.1	56.6	23.3	20.0
1986	4350	.283	21.4	3737	123	14.0	110	.0330	23.5	48.5	28.0	70.3	58.2	24.0	17.8
1987	4134	.278	21.6	3712	131	13.3	113	.0351	19.9	59.6	20.6	72.3	51.9	26.9	21.1
1988	4559	.298	21.2	3841	141	12.9	115	.0366	15.0	57.2	27.8	81.1	53.9	24.9	21.2
1989	4435	.307	20.9	3921	146	12.8	116	.0372	13.9	58.9	27.2	81.9	50.3	28.8	20.9
1990	3805	.302	20.7	4005	151	12.6	117	.0377	13.4	57.1	29.6	80.3	48.2	33.2	18.6
1991	4049	.322	21.3	3948	150	12.6	117	.0379	11.4	67.2	21.4	79.7	47.4	25.5	27.0
1992	4064	.334	20.8	4055	155	12.5	118	.0382	10.4	64.0	25.6	82.2	45.3	30.0	24.7
1993	4754	.360	21.0	4073	162	12.1	120	.0398	8.8	65.3	25.9	82.6	42.1	30.3	27.6
1994	5572	.398	20.8	4129	166	12.0	121	.0402	9.8	62.5	27.7	83.4	46.5	25.1	28.4
1995	5749	.380	20.5	4184	168	12.0	121	.0401	8.6	63.5	27.9	80.8	39.5	28.9	31.6
1996	5254	.400	20.8	4224	179	11.5	124	.0423	6.5	67.1	26.4	84.7	37.2	26.8	36.0
1997	6108	.423	20.6	4344	187	11.4	126	.0429	10.1	52.5	37.4	83.0	39.3	20.3	40.3
1998	6477	.448	20.9	4282	187	11.2	126	.0435	8.9	58.7	32.4	83.0	37.3	23.0	39.8
1999	7276	.458	20.4	4356	193	11.1	127	.0442	10.8	54.8	34.4	78.0	40.2	21.0	38.8
2000	7381	.461	20.5	4432	200	11.0	129	.0449	8.5	52.9	38.6	77.2	36.4	19.9	43.6
Both Cars and Trucks															
1975	10224	1.000	15.3	4060	137	14.1	112	.0335	46.8	23.5	29.8	82.9			
1976	12334	1.000	16.7	4079	135	14.3	111	.0328	45.6	24.2	30.3	86.2			
1977	14123	1.000	17.7	3981	136	13.8	112	.0339	43.8	23.7	32.5	83.5			
1978	14448	1.000	18.6	3715	129	13.6	112	.0344	37.0	31.7	31.2	82.2			
1979	13882	1.000	18.7	3655	124	13.9	110	.0335	37.3	30.9	31.7	81.4			
1980	11306	1.000	22.5	3227	104	14.3	107	.0320	50.1	31.6	18.3	70.9			
1981	10554	1.000	24.1	3201	102	14.4	107	.0318	46.6	33.4	20.0	71.7			
1982	9732	1.000	24.7	3201	103	14.4	107	.0320	49.6	31.0	19.5	71.6			
1983	10302	1.000	24.6	3257	107	14.1	108	.0327	44.9	34.9	20.1	72.7			
1984	14020	1.000	24.6	3261	109	14.0	109	.0332	48.4	33.4	18.2	76.3			
1985	14460	1.000	25.0	3271	114	13.5	110	.0347	46.5	33.9	19.7	74.2			
1986	15365	1.000	25.7	3237	114	13.4	111	.0351	49.3	33.7	17.0	68.8			
1987	14865	1.000	25.9	3220	118	13.1	112	.0361	51.4	34.1	14.5	64.6			
1988	15295	1.000	25.9	3283	123	12.8	114	.0372	50.0	32.7	17.3	67.1			
1989	14453	1.000	25.4	3351	129	12.5	115	.0382	44.7	37.6	17.7	68.1			
1990	12615	1.000	25.2	3426	135	12.2	117	.0394	44.9	37.2	17.8	63.9			
1991	12573	1.000	25.4	3409	138	12.1	118	.0402	45.3	39.4	15.2	63.8			
1992	12172	1.000	24.9	3512	145	11.8	120	.0413	41.1	39.9	19.0	66.3			
1993	13211	1.000	25.1	3518	147	11.8	120	.0416	39.8	42.4	17.8	68.4			
1994	13986	1.000	24.6	3600	152	11.7	121	.0420	39.1	40.6	20.3	66.7			
1995	15145	1.000	24.7	3612	158	11.3	123	.0438	38.8	41.9	19.3	67.0			
1996	13144	1.000	24.8	3658	164	11.1	125	.0447	35.2	46.0	18.7	68.6			
1997	14442	1.000	24.5	3726	169	11.0	126	.0452	36.1	39.8	24.1	66.9			
1998	14445	1.000	24.5	3744	172	10.9	126	.0457	31.2	48.0	20.8	67.6			
1999	15884	1.000	24.0	3819	178	10.8	128	.0464	30.9	46.1	23.0	64.7			
2000	16015	1.000	24.0	3868	183	10.6	129	.0473	28.7	43.2	28.1	62.2			

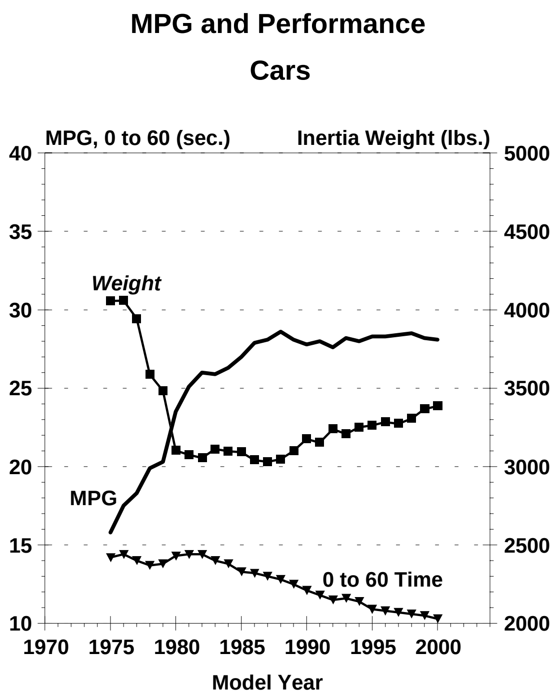

Figure 6

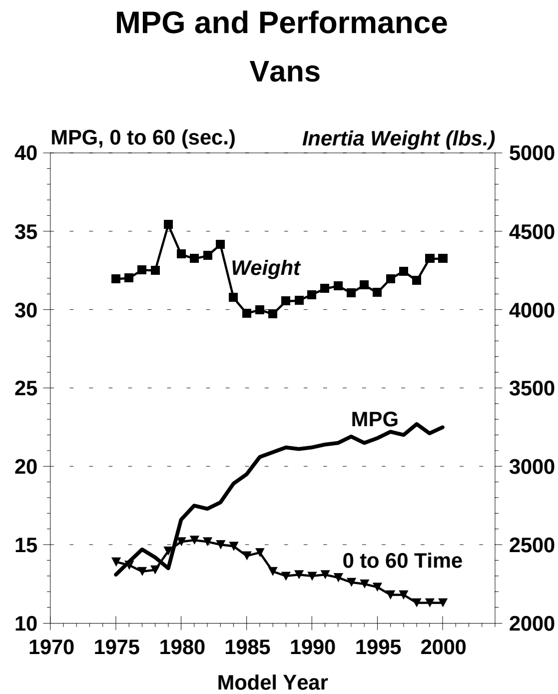

Figure 7

As indicated in Table 4, average inertia weight for trucks reached a minimum value of 3737 pounds in 1986 and has increased nearly 700 pounds since then. Between 1975 and 1984, estimated 0-to-60 time for trucks increased from 13.6 to 14.7 seconds and has since decreased to 11.0 seconds. For model year 2000, light-truck fuel economy is nearly 50% higher than it was in 1975, but most of this increase occurred between 1975 and 1981.

The sales distribution by truck type has changed considerably in recent years. In 1975, pickups accounted for two-thirds of truck sales compared to slightly over a third this year. Currently, about 20% of trucks are vans, but in 1990 nearly a third were. Since 1975, the relative sales fraction for SUVs has increased by a factor of more than four; from less than 10% of all light trucks in the mid-70's to more than 40% this year.

Figure 7 shows the changes in weight, fuel economy, and 0-to-60 time that have occurred for vans. Their fuel economy increased by 4.6 mpg between 1975 and 1983, by another 4.2 mpg between then and 1993, and is currently near the peak value of 22.7 attained in 1998. Average weight for vans reached a peak of over 4500 pounds in 1979, dropped to a minimum value of slightly less than 4000 pounds in 1987, and has since increased by over 350 pounds. Zero-to-60 time for vans peaked at 15.3 seconds

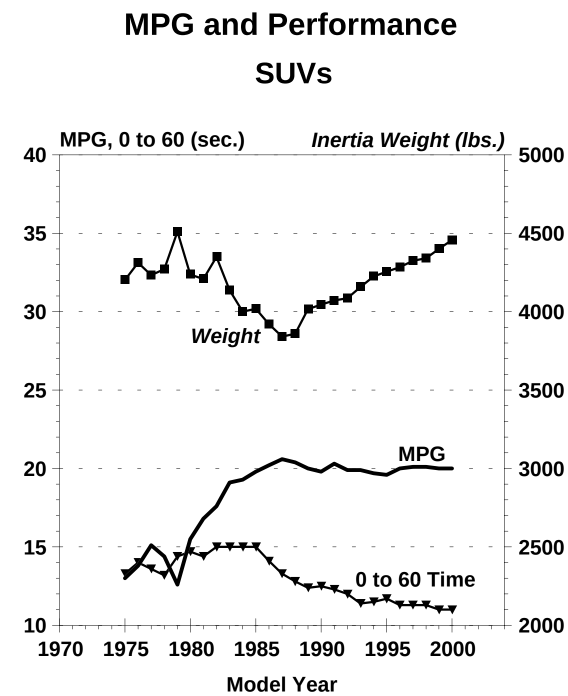

Figure 8

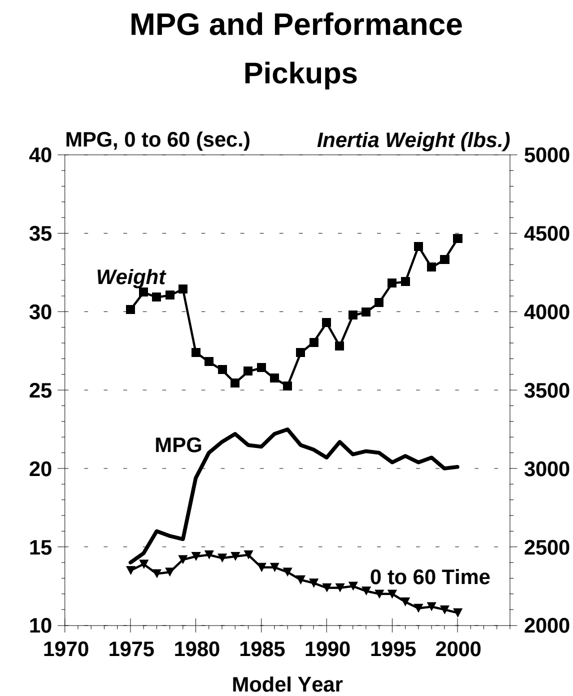

Figure 9

in 1981, and they are now about four seconds faster. Many of the changes in vans can, of course, be attributed to the introduction and popularity of “Minivans” and the related use of front-wheel drive. Through 1983, vans were essentially all rear drive. In 1984, van front-wheel drive usage jumped to over 20% and more than doubled by 1990. Since 1998, more than three-fourths of vans have used front-wheel drive.

Figure 8 shows similar data for SUVs which accounted for less than about 5% of all light-duty vehicles each year through 1984 compared to 20% this year. For MY2000, the sales fraction of SUVs will be higher than the combined sales fraction for vans, pickups, and SUVs was in 1975. SUV inertia weight peaked at over 4500 pounds in 1979, dropped to a minimum of 3921 pounds in 1986, and has since increased by over 500 pounds. This increase in SUV inertia weight has been accompanied by a decrease in 0-to-60 time and relatively constant fuel economy. For the past fifteen years, SUV fuel economy has averaged within 0.5 mpg of 20.1.

The trend for pickup trucks (Figure 9) has been very similar to that for SUVs. Their inertia weight reached 4142 pounds in 1978, decreased to about 3500 pounds in the mid-80's, and they are now nearly 900 pounds heavier. For MY2000, their fuel

Estimated Top Speed by Model Year

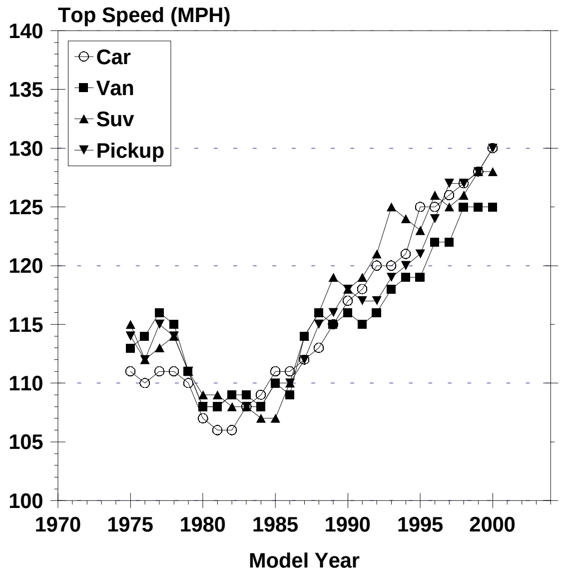

Figure 10

Ton-MPG by Model Year

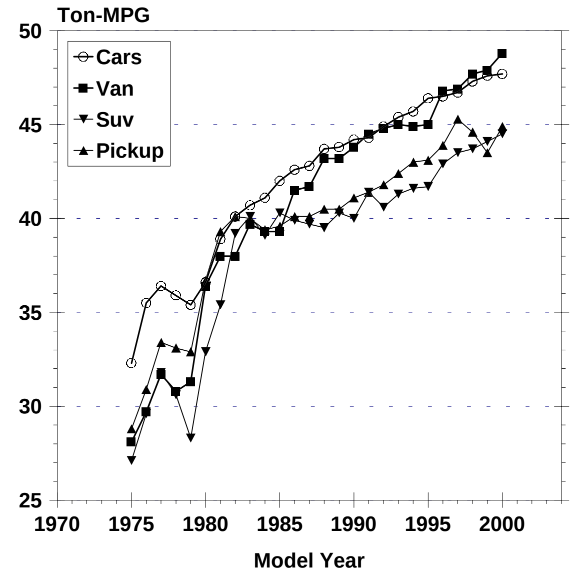

Figure 11

economy will be about 11% lower than the maximum value attained in 1987. Their average 0-to-60 time has decreased almost continuously and is now nearly four seconds faster than it was in 1984. Figure 10 compares another estimated performance metric: top speed, which like estimated 0-to-60 time is calculated from the ratio of horsepower to weight. The trends for all four vehicle types are very similar and are difficult to distinguish. As with 0-to-60 time, estimated top speed for cars, vans, SUVs, and pickups remained relatively constant for a few years in the late 70's, then dropped slightly during the early 80's, and has since increased from about 110 MPH in 1984 to 125 to 130 MPH this year.

Because the weight increases that have occurred in recent years have not been accompanied by a substantial reduction in mpg, light-duty vehicles are getting more efficient at moving their weight around. Accounting for this in a measure of vehicle efficiency can be accomplished by looking at ton-mpg which, as previously mentioned, is defined for the purpose of this paper as a vehicle’s weight in tons times its mpg. Since 1975, cars have improved in ton-mpg by about 50%, pickups by about 55%, SUVs by 65%, and vans by about 75%. Vans and cars now have about the same ton-mpg, but SUVs and pickup trucks lag behind (see Figure 11) by about five ton-mpg and by about a half dozen years.

III. <u>Trends by Vehicle Type and Size Class</u>

Figure 1 and Table 1 show that trucks are expected to account for over 46% of the light-duty vehicles produced during model year 2000. In the next series of figures and tables, cars and light trucks are classified into five vehicle types: cars (i.e., coupes, sedans, and hatchbacks) station wagons, vans, sports utility vehicles (SUVs), and pickup trucks; and three vehicle sizes: small, midsize, and large. Note that vehicles have not been produced recently for Small Vans and Large Wagons. Appendix E contains a series of tables describing light-duty vehicles at the vehicle size/type level of stratification.

Table 5 compares sales fractions by vehicle type and size for model years 1975, 1988, and 2000. Since 1975, the largest increases in sales fraction on this basis have been for midsize SUVs and midsize vans. These two truck-size classes are expected to account for over 20% of the vehicles built this year, compared to a combined total of about 4 and 10% in 1975 and 1988, respectively. Conversely, the largest sales fraction decrease has occurred for small cars which accounted for 40% of all light-duty vehicles produced in both 1975 and nearly 44% in 1988. While their sales fraction has consistently remained the largest of the 15 vehicle sizes and types, it has since decreased to about 20% and thus is about half what it was in 1975. Midsize cars have also consistently retained their number two ranking and for model year 2000 will have a slightly larger (i.e., 3.5%) sales fraction as in 1978.

An overall decrease has occurred for large cars which accounted for about 15% of total light-duty sales in 1975 when they ranked third. Between then and 1988, their sales fraction dropped almost in half but has increased this year back above 10%. Part of this increase can be attributed to design changes made since last year of the Ford Taurus Sedan. For MY2000, the interior volume of this relatively popular vehicle increased by about five cubic feet (from 116.7 to 121.7), moving it from the Midsize Car Class to the Large Car Class. The MY2000 Taurus's combined passenger and cargo volume is thus 1.7 cubic feet (i.e., 1.4%) more than EPA's minimum for the Large Car Class. Since 1997, the sales fraction for Large Cars has ranked fifth and is now behind Midsize Vans and Midsize SUVs.

Table 5 **Sales Fractions of MY1975, MY1988, and MY2000 Light-Duty Vehicles by Vehicle Size and Type**

		Sales Fraction			Change in Sales Fraction		
Vehicle Type	Size	1975	1988	2000	From 1975 To 2000	From 1975 To 1988	From 1988 To 2000
Car	Small	40.0%	43.8%	24.3%	-15.7%	3.9%	-19.5%
	Midsize	16.0%	13.8%	17.3%	1.4%	-2.1%	3.5%
	Large	15.2%	8.5%	10.3%	-4.9%	-6.7%	1.8%
	All	71.2%	66.2%	51.9%	-19.3%	-5.0%	-14.3%
Wagon	Small	4.7%	1.7%	0.6%	-4.1%	-3.0%	-1.1%
	Midsize	2.8%	1.9%	1.4%	-1.4%	-1.0%	-0.5%
	Large	1.9%	0.5%	0.0%	-1.9%	-1.4%	-0.5%
	All	9.4%	4.0%	2.0%	-7.4%	-5.4%	-2.0%
Van	Small	0.0%	0.4%	0.0%	0.0	0.3%	-0.4%
	Midsize	3.0%	6.2%	7.9%	4.9%	3.2%	1.7%
	Large	1.5%	0.9%	1.3%	-0.2%	-0.6%	0.4%
	All	4.5%	7.4%	9.2%	4.7%	2.9%	1.8%
SUV	Small	0.5%	1.9%	2.3%	1.8%	1.4%	0.6%
	Midsize	1.2%	4.0%	12.3%	11.1%	2.8%	8.3%
	Large	0.1%	0.5%	5.5%	5.4%	0.3%	5.0%
	All	1.8%	6.3%	20.1%	18.3%	4.5%	13.7%
Pickup	Small	1.6%	2.2%	1.5%	0.1%	0.7%	-0.7%
	Midsize	0.5%	6.9%	4.2%	3.7%	6.4%	-2.7%
	Large	11.0%	7.0%	11.0%	0.0%	-4.1%	4.1%
	All	13.1%	16.1%	16.8%	3.8%	3.0%	0.7%
All Trucks		19.4%	29.8%	46.1%	26.7%	10.4%	16.3%

Significant sales fraction decreases for station wagons have also occurred. They now account for only 2% of the vehicles that will be sold this year vs. more than 9% in 1975. The sales fraction for pickups, by comparison, has been relatively stable.

Table 6 **Worst, Average, and Best Fuel Economy by Vehicle Type and Size**

Vehicle Type	Size	1975 Worst	1975 Avg.	1975 Best	1988 Worst	1988 Avg.	1988 Best	2000 Worst	2000 Avg.	2000 Best
Car	Small	10.1	18.7	33.2	8.7	30.5	65.6	11.7	30.2	76.3
	Midsize	10.1	13.5	13.6	12.4	26.6	32.8	15.0	27.1	35.5
	Large	9.8	13.0	13.1	11.8	24.2	30.8	16.1	25.4	28.1
	All	9.8	15.8	33.2	8.7	28.7	65.6	11.7	28.1	76.3
Wagon	Small	13.9	22.4	28.2	20.4	31.3	39.5	20.5	28.5	37.9
	Midsize	9.8	13.2	29.4	20.8	26.2	32.8	22.9	27.4	33.9
	Large	9.8	11.9	15.1	22.6	22.8	22.9	----	----	----
	All	9.8	16.1	29.4	20.4	27.6	39.5	20.5	27.7	37.9
Van	Small	19.1	20.6	21.6	18.5	24.5	29.6	----	----	----
	Midsize	9.7	13.3	21.5	13.4	21.8	27.7	18.5	23.4	25.9
	Large	10.5	12.6	17.0	11.8	16.9	19.9	15.0	18.2	19.6
	All	9.7	13.1	21.6	11.8	21.2	29.6	15.0	22.5	25.9
SUV	Small	12.0	16.1	19.2	18.6	24.2	33.3	18.9	23.5	31.1
	Midsize	9.6	12.1	21.5	12.1	19.5	28.1	15.4	20.8	27.5
	Large	9.2	12.2	16.0	14.5	16.6	22.1	15.5	17.3	20.8
	All	9.2	13.0	21.5	12.1	20.4	33.3	15.4	20.0	31.1
Pickup	Small	15.2	22.5	24.3	16.0	25.0	29.2	19.4	23.7	28.7
	Midsize	21.0	21.1	21.1	18.2	25.3	30.7	15.5	22.7	29.6
	Large	9.0	13.1	21.6	11.7	18.0	24.8	15.4	18.9	22.8
	All	9.0	14.0	24.3	11.7	21.5	30.7	15.4	20.1	29.6
All	Cars	9.7	15.8	33.2	8.7	28.6	65.6	11.7	28.1	76.3
All	Trucks	9.0	13.7	24.3	11.7	21.2	33.3	15.0	20.5	25.9
All	Vehicles	9.7	15.3	33.2	8.7	25.9	65.6	11.7	24.0	76.3

Table 6 compares the changes in fuel economy that have occurred by vehicle size and type for the same model years shown in Table 5. With two exceptions, average fuel economy for all of the thirteen vehicle size and type classes that are represented by MY2000 vehicles is higher this year than Small Cars were in 1975. For MY2000, however, Large SUVs and Large Vans will average 17.3 and 18.2 mpg, respectively, compared to 18.7 mpg that Small Cars attained in 1975.

Small, midsize, and large cars have all achieved double-digit mpg increases since 1975 with most of this increase (see Figures 12, 13, and 14) coming by the mid-1980's. Fuel economy increases since 1975 for the nine truck vehicle size/types have all been less than 10 mpg with small and midsize pickups on both a percentage (see Table 6) and absolute basis achieving the smallest improvement, namely less than 2 mpg. It should be noted that for MY2000 large cars get higher fuel economy than all nine of the truck classes. In addition, five of the truck size/type classes (midsize vans, small and midsize SUVs, and small and midsize pickups) get higher average mpg this year, than small, midsize, and large cars did in 1975. For example, MY2000 midsize SUVs will average 20.8 mpg in this year, compared to 18.7, 13.5, and 13.0 mpg, respectively, for MY1975 small, midsize, and large cars.

Since 1988, average fuel economy has decreased for five of the fifteen vehicle types. In addition, average fuel economy for all cars and trucks and the combined car and truck fleet has decreased by about 2%, 3%, and 7%, respectively, since then. At the vehicle size and type level of stratification, between 1975 and this year, the rate of fuel economy improvement for the least fuel efficient vehicles has been significantly less than that for both the class average and the most efficient vehicle. In fact, in three cases (Small Cars, Midsize Pickups, and Small Vans), the fuel economy of the worst vehicles was lower in 1988 than it was in 1975. A similar decrease also occurred for the worst Midsize Pickups between 1988 and this year.

With four exceptions (Small Cars, Midsize Wagons, Large Vans, and Large Pickups), the average fuel economy achieved in 1988 was higher than that of the best vehicle in that class in 1975. For example, in 1988, Midsize Cars averaged 26.6 mpg compared to 13.6 mpg for the best Midsize Car in 1975. The fuel economy of the best vehicle in each strata for 1988, however, is always higher than the corresponding average for this year.

Figure 3 shows relative vehicle lifetime fuel consumption at the vehicle type level of stratification. Table 8 includes similar data to that in Figure 3, but at the vehicle type and size level of stratification. As relative sales fractions changed and vehicle fuel economy improved, changes in relative vehicle lifetime fuel consumption have occurred. Since 1975, this metric has decreased by 26% for the three car classes, with over half of this decrease coming from small cars. Similarly, relative lifetime fuel consumption for wagons has decreased from about 9% in 1975 to less than 2% this year.

Table 7 **Percent Change in Worst, Average, and Best Fuel Economy by Vehicle Type and Size**

Vehicle Type	Size	From 1975 to 2000 Worst	Avg.	Best	From 1975 to 1988 Worst	Avg.	Best	From 1988 to 2000 Worst	Avg.	Best
Car	Small	16%	61%	130%	-14%	63%	98%	34%	-1%	16%
	Midsize	49%	101%	161%	23%	97%	141%	21%	1%	8%
	Large	64%	95%	115%	20%	86%	135%	36%	5%	-9%
	All	19%	78%	130%	-11%	82%	98%	34%	-2%	16%
Wagon	Small	47%	27%	34%	47%	40%	40%	0%	-9%	-4%
	Midsize	134%	108%	15%	112%	98%	12%	10%	5%	3%
	Large	---	---	---	131%	92%	52%	---	---	---
	All	109%	72%	29%	108%	71%	34%	0%	0%	-4%
Van	Small	---	---	---	-3%	19%	37%	---	---	---
	Midsize	91%	76%	20%	38%	64%	29%	38%	7%	-6%
	Large	43%	44%	15%	12%	34%	17%	27%	8%	-2%
	All	55%	72%	20%	22%	62%	37%	27%	6%	-13%
SUV	Small	58%	46%	62%	55%	50%	73%	2%	-3%	-7%
	Midsize	60%	72%	28%	26%	61%	31%	27%	7%	-2%
	Large	68%	42%	30%	58%	36%	38%	7%	4%	-6%
	All	67%	54%	45%	32%	57%	55%	27%	-2%	-7%
Pickup	Small	28%	5%	18%	5%	11%	20%	21%	-5%	-2%
	Midsize	-26%	8%	40%	-13%	20%	45%	-15%	-10%	-4%
	Large	71%	44%	6%	30%	37%	15%	32%	5%	-8%
	All	71%	44%	22%	30%	54%	26%	32%	-7%	-4%
All	Cars	19%	78%	160%	-11%	81%	123%	34%	-2%	16%
All	Trucks	67%	50%	7%	30%	55%	37%	28%	-3%	22%
All	Vehicle	30%	57%	160%	-3%	69%	123%	34%	-7%	16%

Table 8 **Relative Lifetime Fuel Consumption of MY75, MY88, and MY2000 Light-Duty Vehicles by Vehicle/Type and Size**

		Percent of Fuel Consumed			Change From:		
Vehicle Type	Size	1975	1988	2000	1975 To 2000	1975 To 1988	1988 To 2000
Car	Small	32.0%	34.9%	17.5%	-14.5%	2.9%	-17.4%
	Midsize	17.2%	12.5%	13.9%	-3.4%	-4.7%	1.4%
	Large	17.1%	8.5%	8.7%	-8.3%	-8.6%	0.3%
	All	66.3%	55.9%	40.1%	-26.2%	-10.4%	-15.8%
Wagon	Small	3.1%	1.3%	0.4%	-2.6%	-1.8%	-0.8%
	Midsize	3.1%	1.7%	1.1%	-2.0%	-1.4%	-0.6%
	Large	2.4%	0.5%	----	-2.4%	-1.8%	-0.5%
	All	8.6%	3.5%	1.6%	-7.0%	-5.0%	-1.9%
Van	Small	----	0.4%	----	0.0%	0.4%	-0.4%
	Midsize	3.9%	8.2%	8.8%	4.9%	4.3%	0.6%
	Large	2.1%	1.5%	1.8%	-0.2%	-0.6%	0.3%
	All	6.0%	10.2%	10.6%	4.6%	4.1%	0.5%
SUV	Small	0.6%	1.9%	2.2%	1.6%	1.3%	0.3%
	Midsize	1.8%	5.9%	15.4%	13.6%	4.2%	9.4%
	Large	0.2%	0.8%	8.2%	8.1%	0.6%	7.4%
	All	2.5%	8.6%	25.8%	23.3%	6.1%	17.2%
Pickup	Small	1.2%	2.6%	1.7%	0.5%	1.4%	-0.9%
	Midsize	0.5%	7.9%	4.9%	4.4%	7.5%	-3.1%
	Large	14.9%	11.2%	15.3%	0.4%	-3.6%	4.0%
	All	16.6%	21.8%	21.8%	5.3%	5.2%	0.1%
All	Trucks	33.7%	44.1%	59.9%	26.2%	10.4%	15.8%

Significant increases in relative lifetime fuel consumption have occurred for three of the nine truck vehicle size/type classes: midsize vans, midsize SUVs, and large SUVs. The combined lifetime fuel consumption for these three classes is up by over 25% since 1975. These three classes now account for nearly a third of all lifetime fuel consumption compared to about 6% in 1975. Conversely, relative lifetime fuel consumption for large pickups for MY2000 is about 15%, essentially the same as in 1975.

Figures 6 through 9 compare mpg, inertia weight, and 0-to-60 time for cars, vans, SUVs, and pickup trucks. Figures 12 to 31 make similar comparisons by vehicle size and type.

At this level of stratification, the trends observed earlier for passenger cars for inertia weight, mpg, and 0-to-60 time repeat. In the late 1970's, increases in mpg for these vehicles were accompanied by decreases in inertia weight and relatively constant 0-to-60 times. Since then, as shown in Figures 12 to 15, mpg for the small, midsize, and large cars has been relatively stagnant, decreases in 0-to-60 time have occurred for all three car sizes, and significant increases in weight have occurred for small and midsize cars. Inertia weight for large cars has fluctuated in a narrow range (i.e., 3696 to 3894 pounds) since dropping below the 4000-pound mark in 1985. The trends for wagons (see Figures 16 to 18) are very similar to that for cars.

As indicated in Figure 15, the relative sales fractions of small, midsize, and large cars have been stable, particularly since 1980 and also when compared to the sales fractions of other vehicle types shown in Figures 19, 23, 27, and 31. The impact of the redesign of the MY2000 Ford Taurus, mentioned above, accounts for many of the recent changes in the relative sales fraction of large cars.

As shown in Figure 20, mpg for small vans increased over 25% between 1975 and 1996, the latest year in which any were built. During this time their weight remained relatively stable, but their 0-to-60 time dropped seven seconds. Similarly, fuel economy for midsize vans (see Figure 21) increased by 8.5 mpg between 1975 and 1988 but only 1.6 mpg since then. Their inertia weight increased from 4230 pounds in 1975 to over 4500 pounds in 1979, then dropped to a minimum of 3945 pounds in 1985 but is now about where it was in 1975. Estimated 0-to-60 time for this vehicle size/type remained at about 14 to 15 seconds through 1986 but has declined about three seconds since then. Large vans show an increasing trend in inertia weight and are now roughly 1000 pounds heavier than they were in the late 1975's. Their fuel economy increased from 12.6 mpg in 1975 to 16.8 in 1981 but has yet to surpass the 19 mpg level (see Figure 22).

As indicated in Figures 24 to 26, small SUV inertia weight has ranged from a low of about 2800 pounds in 1983 to a high of almost 3700 pounds this year. Small SUV fuel economy peaked at 28.5 mpg in 1996 when their weight dropped below 2900 pounds. Their 0-to-60 time increased to over 15 seconds in 1985 and has since dropped almost 25%. From 1975 to 1985, midsize SUV weight decreased by over 700 pounds, their 0-to-60 time remained the same, and fuel economy increased from about 12 to 20 mpg.

MPG and Performance

Small Cars

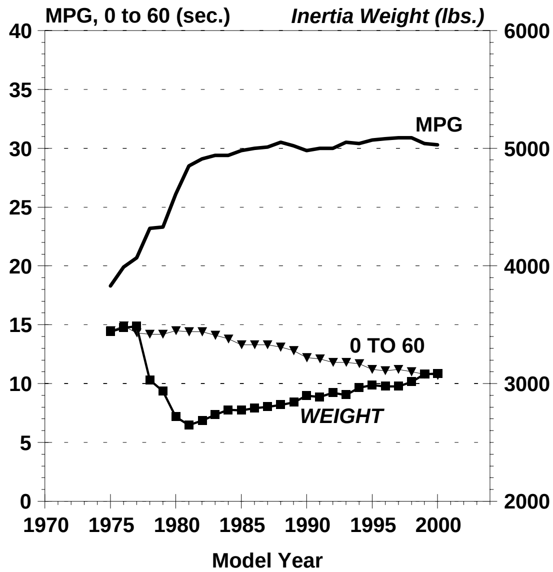

Figure 12

MPG and Performance

Midsize Cars

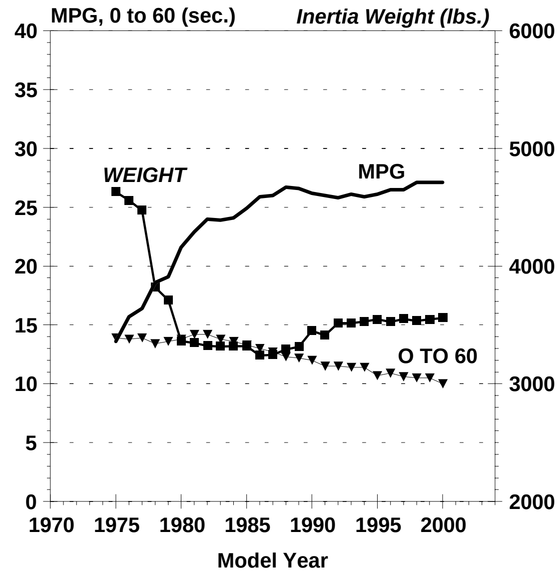

Figure 13

MPG and Performance

Large Cars

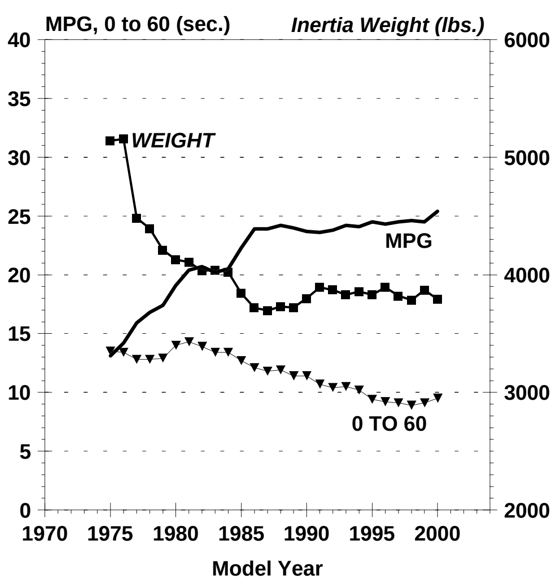

Figure 14

Car Sales Fraction by Vehicle Size

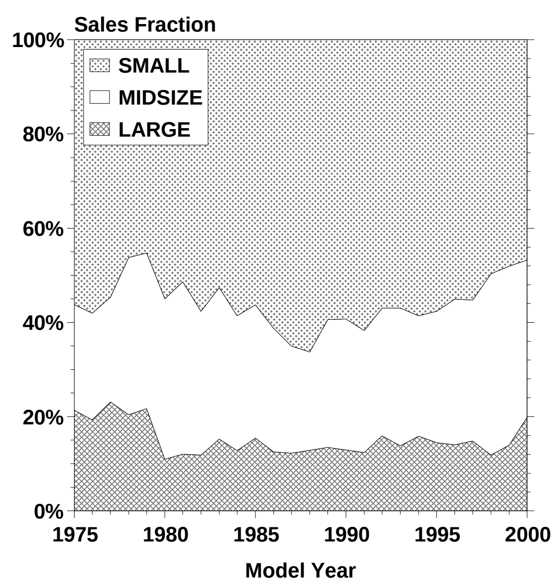

Figure 15

MPG and Performance
Small Wagons

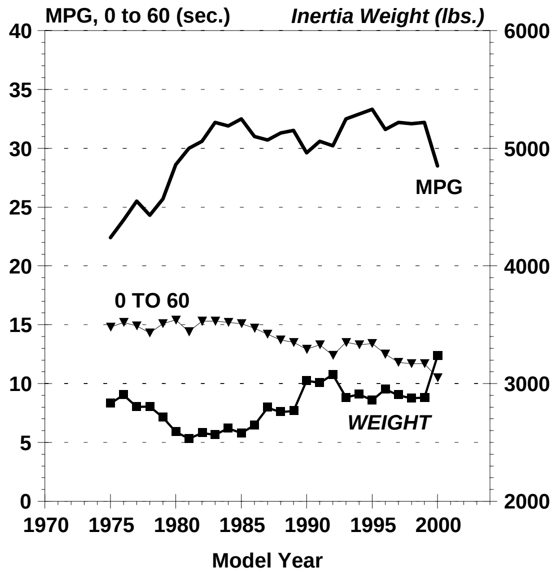

Figure 16

MPG and Performance
Midsize Wagons

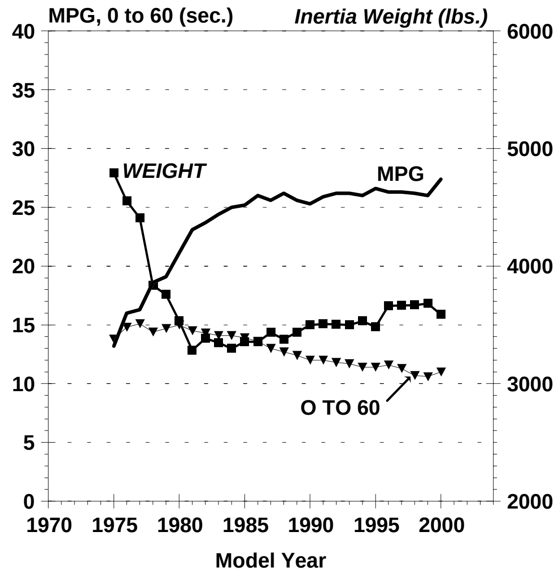

Figure 17

MPG and Performance
Large Wagons

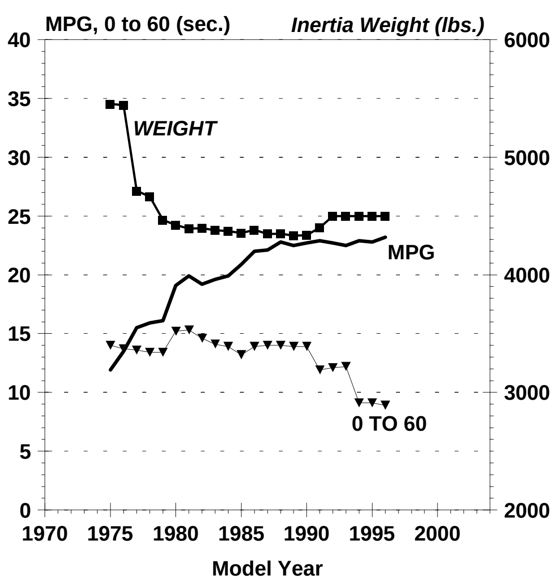

Figure 18

Wagon Sales Fraction by Vehicle Size

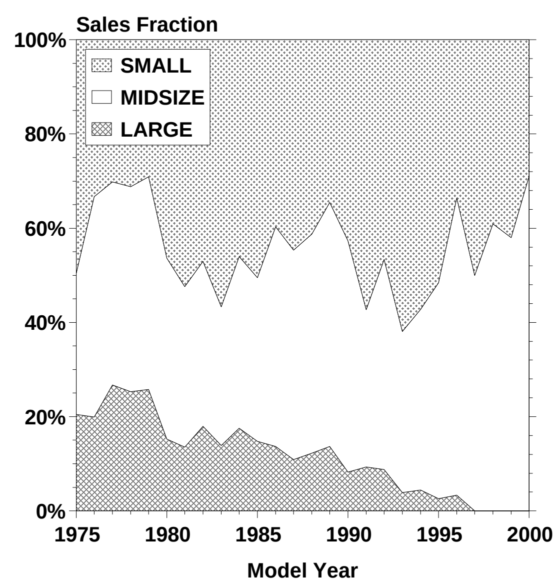

Figure 19

MPG and Performance
Small Vans

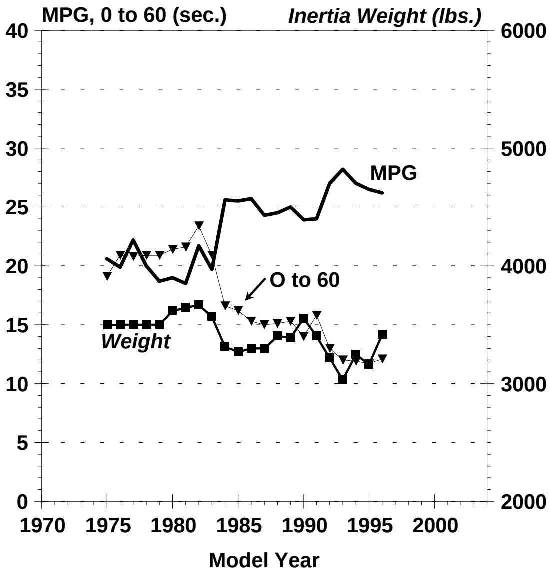

Figure 20

MPG and Performance
Midsize Vans

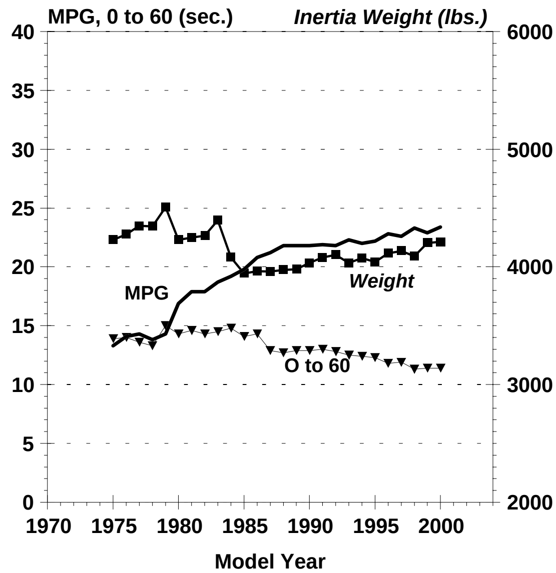

Figure 21

MPG and Performance
Large Vans

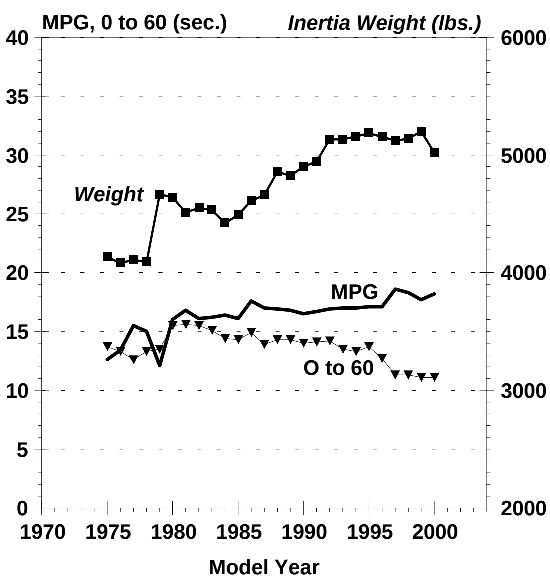

Figure 22

Van Sales Fraction by Vehicle Size

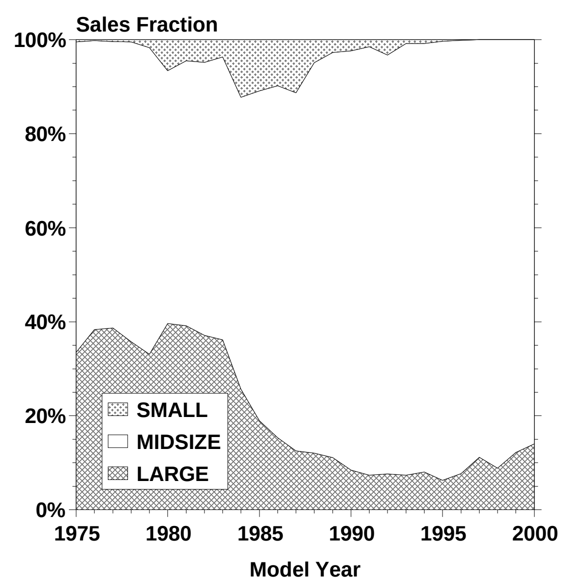

Figure 23

MPG and Performance
Small SUVs

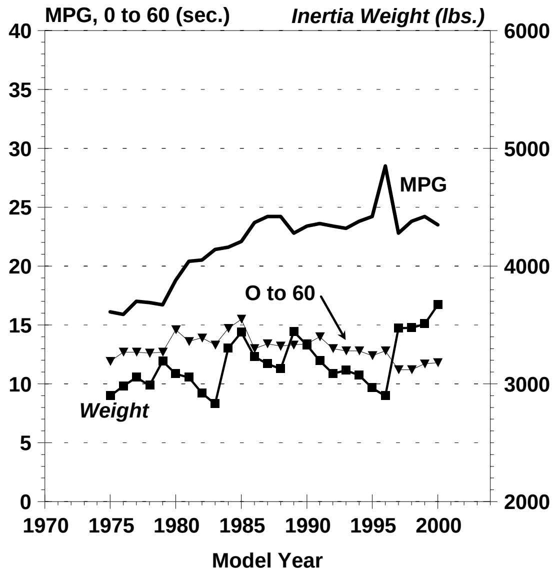

Figure 24

MPG and Performance
Midsize SUVs

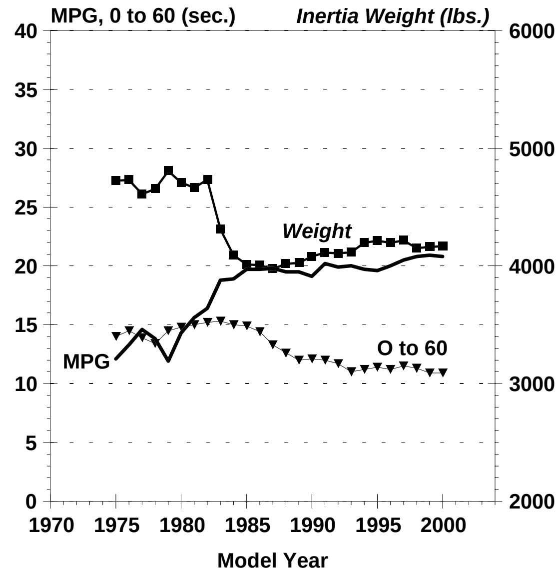

Figure 25

MPG and Performance
Large SUVs

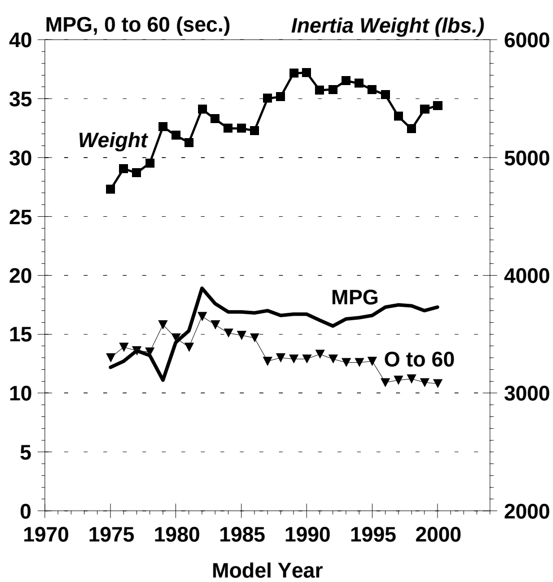

Figure 26

SUV Sales Fraction by Vehicle Size

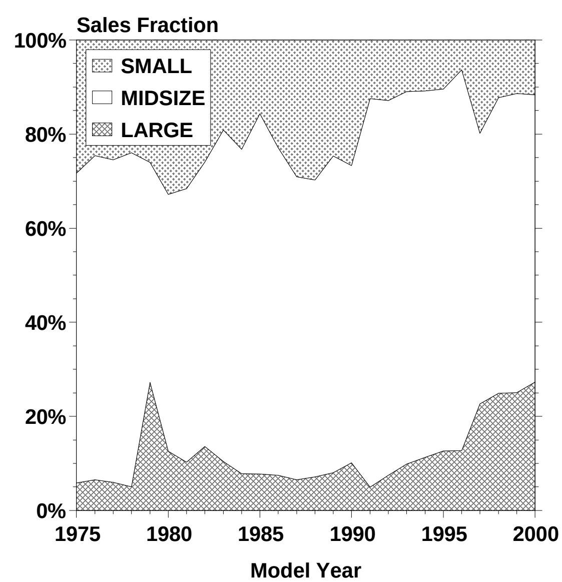

Figure 27

MPG and Performance
Small Pickups

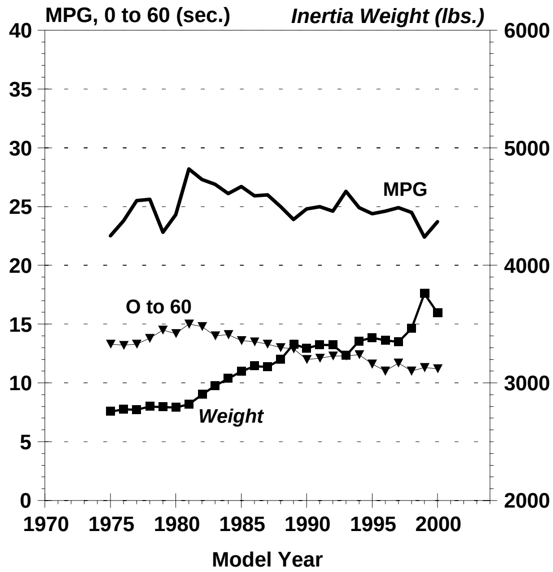

Figure 28

MPG and Performance
Midsize Pickups

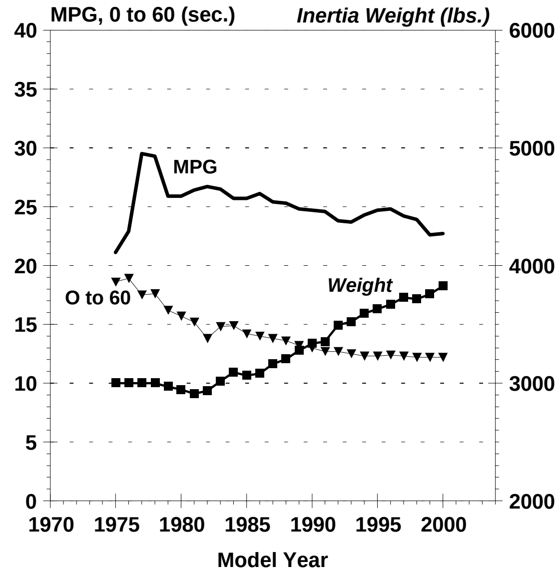

Figure 29

MPG and Performance
Large Pickups

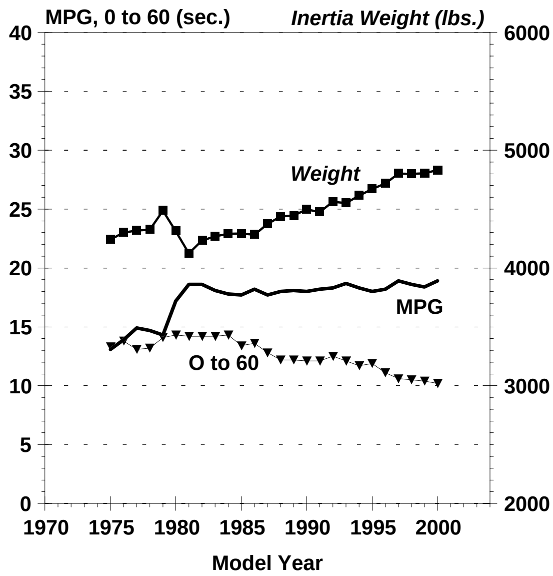

Figure 30

Pickup Sales Fraction by Vehicle Size

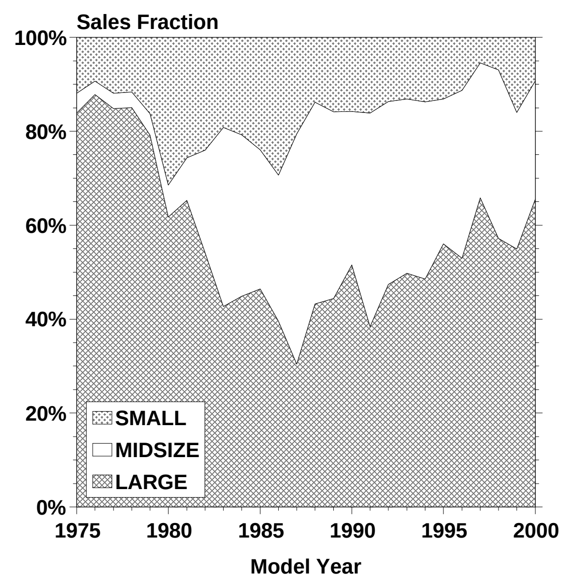

Figure 31

As shown in Figure 26, fuel economy for large SUVs increased from 12.2 mpg in 1975 to 18.9 mpg in 1982 when over half of them had diesel engines. That year, their ton-mpg peaked at 52.7, and their 0-to-60 time exceeded 16 seconds. Large SUV use of diesel engines then declined rapidly and was an order of magnitude lower by 1987. Since 1984, fuel economy for large SUVs has remained relatively stable at about 16 or 17 mpg, but their inertia weight increased from 4728 pounds in 1975 to 5260 in 1979 and has been over 5400 pounds the past two years. Large SUV inertia weight has not been below 5000 pounds in two decades. Figures 13 and 27 show that midsize vehicles have dominated both Vans and SUVs. The relative market share for large SUVs has increased from about 10% in 1975 to over 25% this year (see Figure 27).

Use of diesel engines also accounts for the relatively high fuel economy (i.e., about 28 mpg) that small pickups achieved in 1981 and 1982 when over 22% of them had diesel engines, and they had about a 15-second 0-to-60 time. For MY2000, small pickups will have an inertia weight of nearly 3600 pounds compared to 2756 pounds in 1975; their inertia weight has not been below 3000 pounds since 1984. Their fuel economy remains about 16% below the peak value attained in 1981 (see Figure 28).

As indicated in Figure 29, inertia weight for midsize pickups remained at about 3000 pounds between 1975 and 1986 but has been on an upward trend since then and now exceeds 3800 pounds. Their 0-to-60 time dropped from over 17 to 18 seconds in the late 1970's to about 12 seconds in 1994 where it remains. As a result, their fuel economy remains nearly 25% below the peak value of 29.5 attained in 1977. Large pickups also show a trend toward increasing weight, decreasing 0-to-60 time, and relatively constant fuel economy of about 18 to 19 mpg since 1981, compared to 13.1 mpg in 1975. For MY2000, large pickups have an average inertia weight of 4830 pounds, or nearly 600 pounds more than in 1975 (see Figure 30). As indicated in Figure 31, the relative market share for large pickups has been increasing since the late 1980's.

Figures 32 to 36 compare ton-mpg for small, midsize, and large cars, wagons, vans, SUVs, and pickups. Small, midsize, and large cars cannot be readily distinguished by their ton-mpg trend which has remained in a narrow range that has increased at a relatively consistent rate. The same can be said of small and midsize wagons, but large wagons, which have not been produced since 1996, achieved significantly higher ton-mpg than their smaller counterparts between 1980 and 1986.

Ton-MPG
Cars

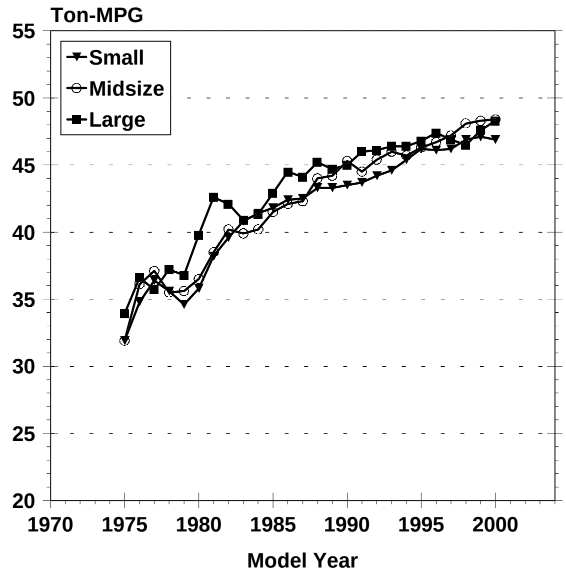

Figure 32

Ton-MPG
Wagons

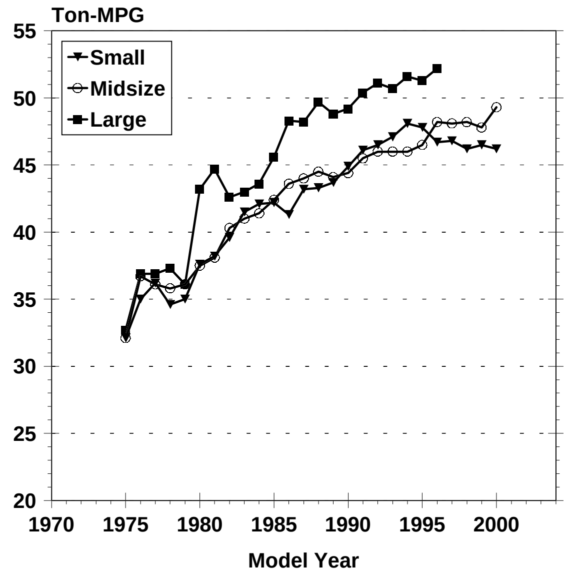

Figure 33

Ton-MPG
Vans

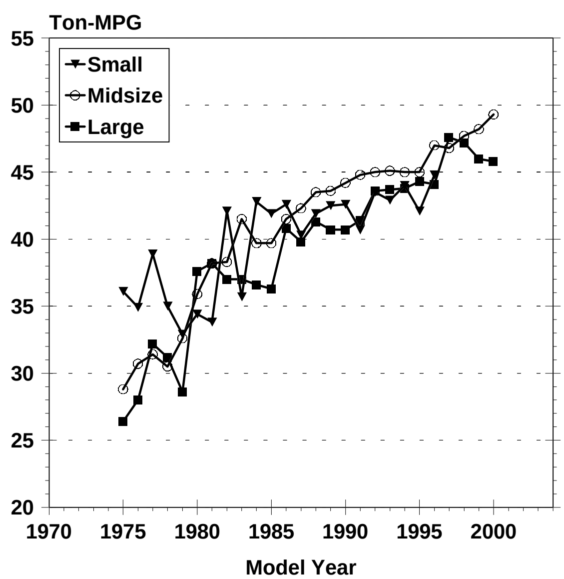

Figure 34

Ton-mpg for all three sizes of vans has also improved consistently, from a nominal 25 to 35 ton-mpg in 1975 to 45 to 50 this year. In 1975, small vans were about 10 ton-mpg higher than their midsize and large counterparts, but by the mid-1980's, this difference had narrowed considerably.

Conversely, since 1980, ton-mpg for large SUVs has been considerably higher than for midsize and small ones. In particular, between 1981 and 1982, the ton-mpg for large SUVs increased by 25%, because over half of them used diesel engines. While large SUV ton-mpg dropped a few years later when diesel popularity waned, it has remained about five ton-mpg higher than that for the two smaller SUV sizes.

A similar trend is noticeable for small pickups for 1981 and 1982, when, as previously mentioned, about 20% of them used diesel engines. Since then, however, small, midsize, and large pickups have had virtually indistinguishable ton-mpg.

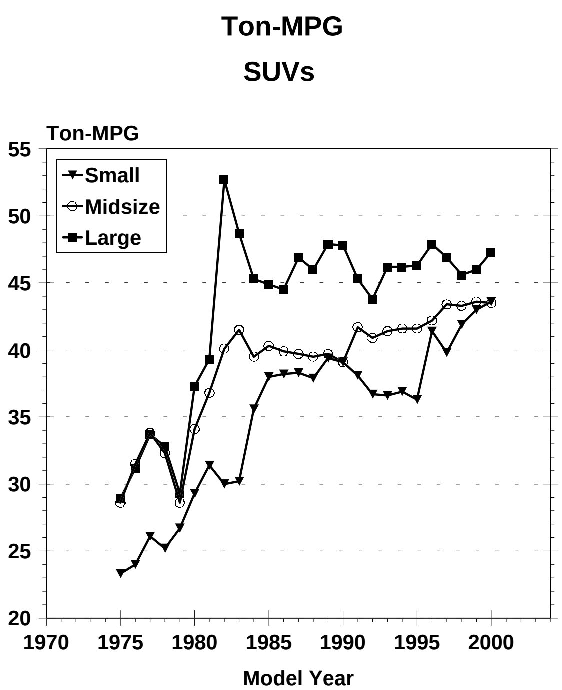

Figure 35

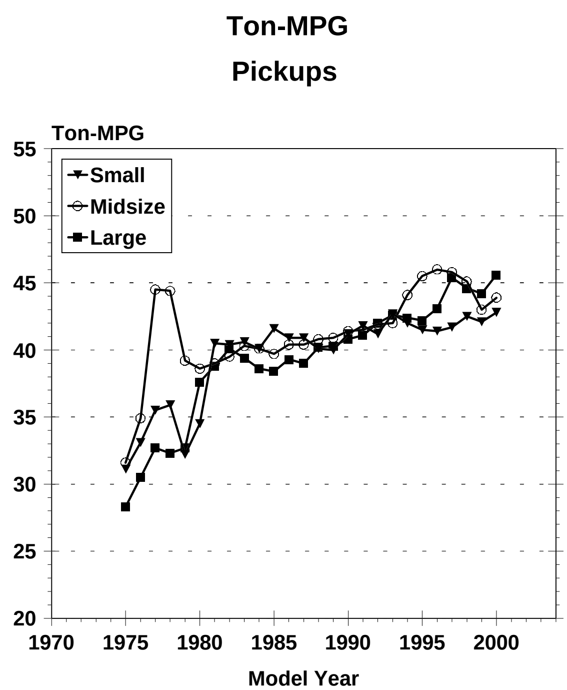

Figure 36

Table 9 compares technology usage for MY2000 by vehicle type and size. For this table, the car classes remain separated into Cars and Station Wagons so that the table stratifies light-duty vehicles into a total of 15 vehicle types and sizes. Note that small vans and large wagons are not represented in this table, because none have been produced since 1996.

Front-wheel drive is used heavily in all of the car and wagon size classes, and nearly 90% of midsize vans now use it. By comparison, none of this year's pickups will have front-wheel drive, and very little use of it is found in large vans or any of the SUVs. Conversely, four-wheel drive is used heavily in SUVs, pickups, and wagons, but very little use of it is made in vans and cars.

Large vehicles make greater use of automatic/lockup transmissions than their midsize or small counterparts. The opposite holds for usage of four-valve engines, with small and midsize vehicles making greater use of this technology than large ones. Domestic vehicles dominate all the midsize and large vehicle types except midsize wagons; imports dominate all of the small vehicles.

Table 9 **MY2000 Technology Usage by Vehicle Type and Size (Percent of Vehicle Type/Strata)**

	Vehicle	Vehicle Type				
Variable	Size	Car	Wagon	Van	SUV	Pickup
Front Wheel Drive	Small	85	60	--	6	0
	Midsize	92	46	88	2	0
	Large	78	--	1	0	0
Four Wheel Drive	Small	2	26	--	69	36
	Midsize	1	52	4	72	26
	Large	0	--	0	73	42
Manual Transmission	Small	26	27	--	45	63
	Midsize	5	14	0	6	40
	Large	0	--	0	0	8
Four Valves Per Cylinder	Small	61	85	--	60	82
	Midsize	69	70	24	25	0
	Large	37	--	0	10	5
Domestic	Small	42	16	--	21	0
	Midsize	38	27	73	69	100
	Large	90	--	99	89	95

IV. Technology Trends

Vehicle technologies studied in this report include usage of front-, rear-, and four-wheel drive transmissions and engines. Appendix D gives data stratified by vehicle type, Appendixes H, I, and J give additional data stratified by vehicle type, by transmission type and number of gears, by number of engine cylinders, and by number of valves per cylinder, respectively.

In Figures 37 to 40, the differences and changes in drivetrain configuration between cars, vans, SUVs, and pickup trucks are apparent. Prior to 1978, less than 10% of cars used front-wheel drive with almost all of the remainder rear drive. Since 1988, more than 80% of cars have used front-wheel drive. Rear-wheel drive accounted for nearly 95% of the 1975 cars; by 1984, its sales fraction dropped below 50%; for the past five years, it has stayed below 15%. For all of the years shown, four-wheel drive has been used in only a few percent of the cars.

Drivetrain usage for vans has also changed substantially. Prior to 1983, virtually all vans used rear drive. Starting with the introduction of the Chrysler minivans in 1984, front drive usage in vans increased to above 20% that year, then reached a nominal 50% in 1993, and has been over 75% for the past three years. With few exceptions (e.g., 1991) four-wheel drive usage in vans has remained relatively small, i.e., less than 5%.

Through 1990, 80% or more of the SUVs have used four-wheel drive, but rear-drive usage in SUVs has since increased from 10 to 15% to over 25%. For the past five years, front drive has been used in a limited number of imported SUVs. Similarly, front drive has been rarely used in pickup trucks with the main exception occurring in the early 1980's. Four-wheel drive usage in pickups has, however, essentially doubled from about 12 to 20% in 1975 to 1977 to about 35 to 40% the past four years.

Two important changes in transmission design have occurred: the addition of a gear for both automatic and manual transmissions and, for the automatics, conversion to lockup (L3, L4, or L5) torque converter transmissions. Figures 41 to 44 indicate that the L4 transmission is currently the predominant transmission type for cars, vans, SUVs, and pickup trucks. Where manual transmissions are used, the 5-speed (M5) transmission now predominates. The increasing trend in ton-mpg discussed earlier can be attributed to better vehicle design, including more efficient engines, better transmission design, and better and better matching of the engine and transmission.

Front, Rear and Four Wheel Drive Usage

Cars

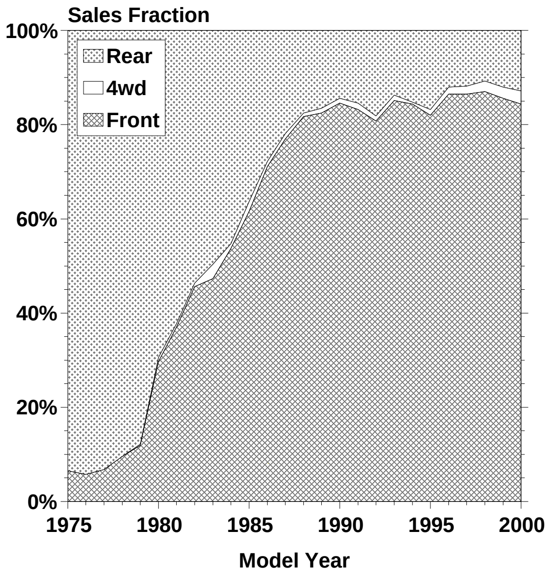

Figure 37

Front, Rear and Four Wheel Drive Usage

Vans

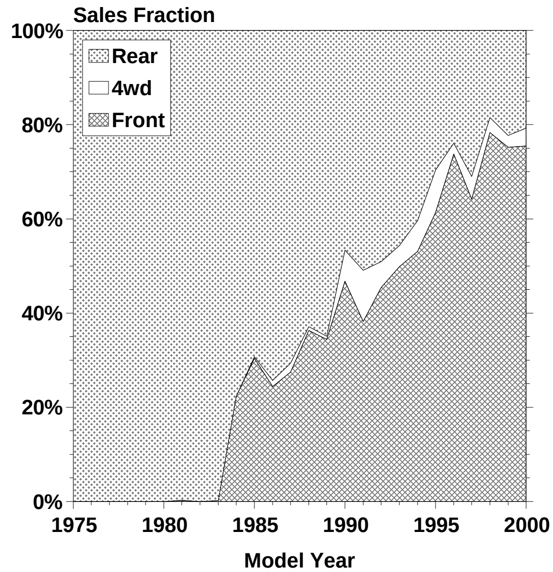

Figure 38

Front, Rear and Four Wheel Drive Usage

SUVs

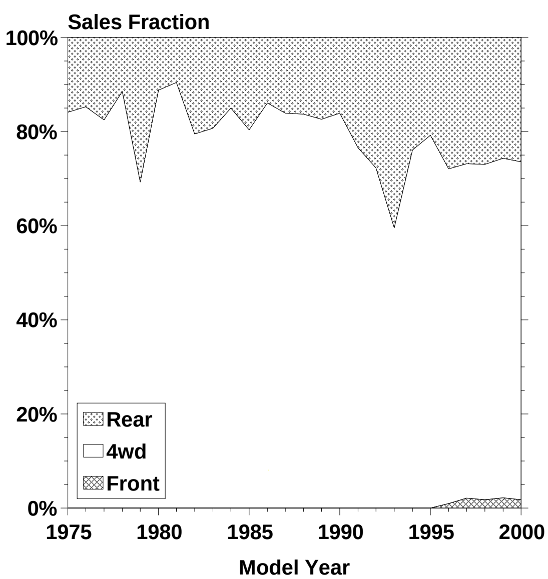

Figure 39

Front, Rear and Four Wheel Drive Usage

Pickups

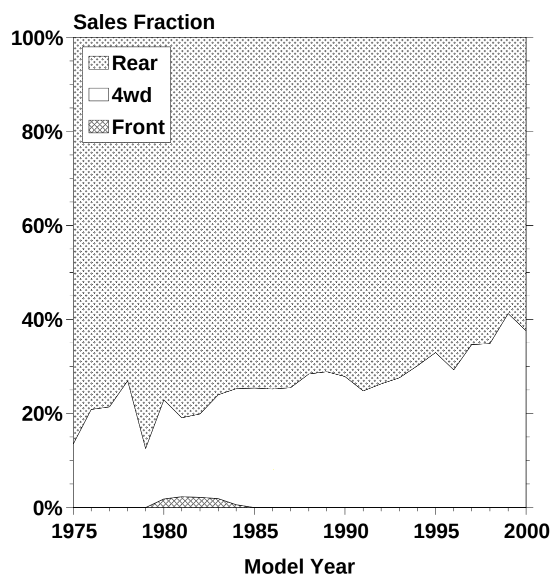

Figure 40

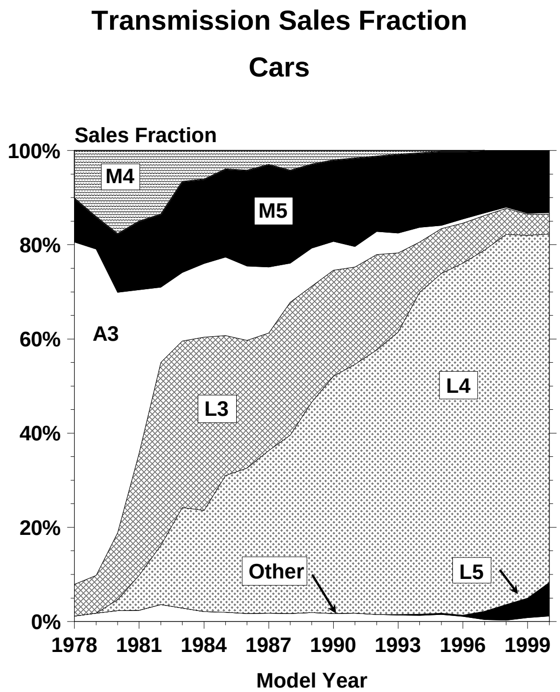

Figure 41

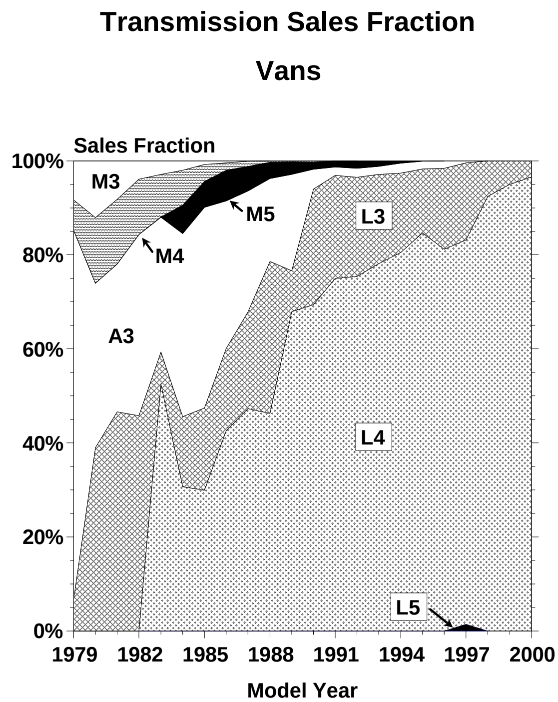

Figure 42

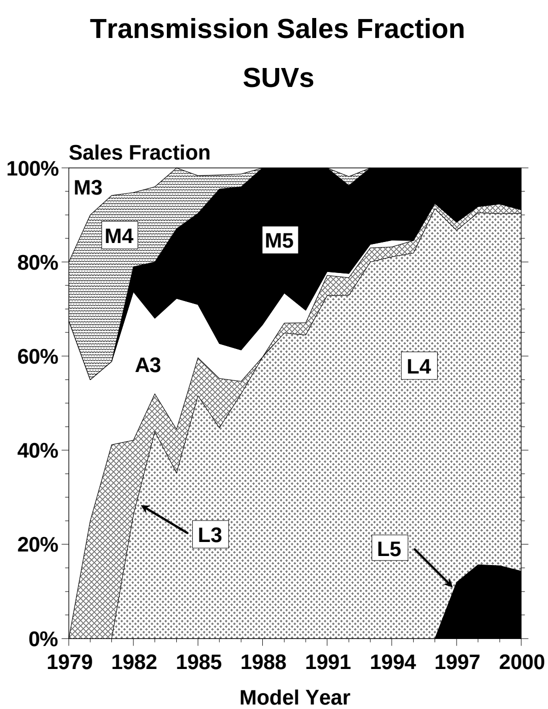

Figure 43

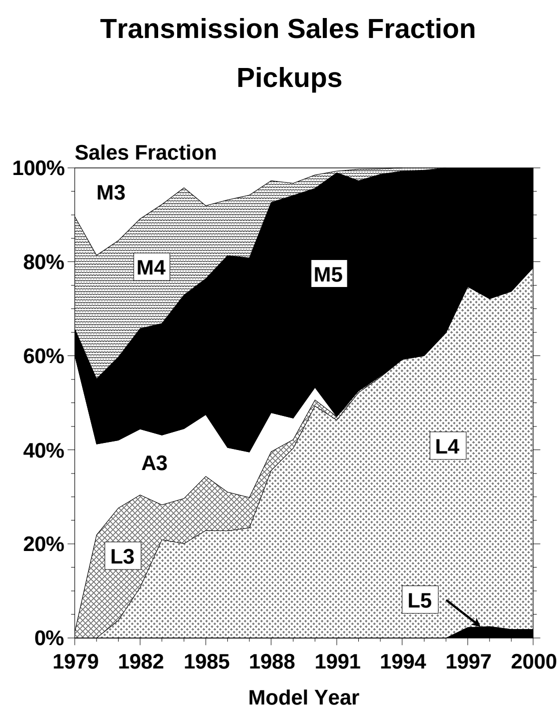

Figure 44

Manual transmission usage peaked slightly above 30% for cars in 1980 and has been below 15% since 1996. Vans have not used manual transmission for five years, compared to a usage rate of 20 to 25% two decades ago. Similarly, manual transmission usage for SUVs has dropped from above 40% in 1975 to less than 10% the past three years. Manual transmission usage for pickups peaked at nearly 60% in 1987 and is now below 25%.

Powertrains are matched to the load better when the engine operates closer to its best efficiency point more of the time. For many conventional engines, this point is approximately 2000 RPM and 2/3 of the maximum torque at that speed. One way to make the engine operate more closely to its best efficiency point is to increase the number of gears in the transmission and, for automatic transmissions, using a lockup torque converter. Figure 45 indicates that, for cars, ton-mpg improves when more transmission gears are added and lockup torque converters used. Typically, ton-mpg improves by about 10% with the addition of a gear and a lockup torque converter. Use of the L5 transmission, which in cars achieves about the same ton-mpg as the M5 does, is beginning to increase and is approaching 10% of the market.

Car Ton-MPG

By Transmission and Number of Gears

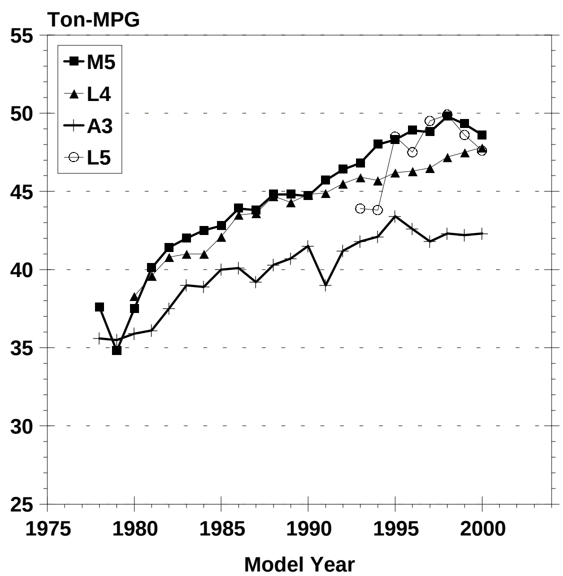

Figure 45

Table 10 compares the improvement in ton-mpg by transmission and vehicle type that occurred between 1988, the peak year for passenger car fuel economy, and this year. For every strata for which the equivalent vehicle type used the same transmission type in both years shown in the table, ton-mpg will be higher this year, than it was in 1988. In addition, usage of L5 transmissions has been increasing in recent years, particularly for cars and SUVs. For model year 2000, cars and SUVs equipped with L5 transmissions will achieve about the same ton-mpg as their M5-equipped counterparts. Similarly, for all four vehicle types, MY2000 vehicles with L4 transmissions achieve the same or better ton-mpg this year than any of the corresponding vehicles did in 1988.

Table 10 **Improvement in Ton-mpg by Transmission and Vehicle Type**

	Car		Van		SUV		Pickup	
Trans	2000	1988	2000	1988	2000	1988	2000	1988
M3	--	--	--	--	--	40	--	40
M4	--	44	--	40	--	45	--	39
M5	49	45	--	45	43	39	46	42
A3	42	40	--	41	--	35	--	38
A4	45	40	--	--	--	35	39	39
L3	45	43	48	44	38	40	--	37
L4	48	45	49	43	45	40	45	40
L5	48	--	--	--	45	--	40	--

Figures 46 to 49 compare the trends since 1975 for horsepower (HP), displacement (CID), and specific power or horsepower per cubic inch (HP/CID) for passenger cars, vans, SUVs, and pickups. In all four cases, significant CID reductions occurred in the late 1970's and early 1980's. Since 1985, however, engine displacement has continued to decrease for cars and vans, but not for SUVs and pickups. For all four vehicle types, average horsepower has increased substantially (i.e., 40 to 80%) since 1981. Light-duty vehicle engines, thus, have also improved in HP/CID, with engines used in passenger cars improving at a faster rate than truck engines. In fact, for the past two years, car engines have averaged at least 1.0 HP/CID, compared to 0.85, 0.79, and 0.84, respectively, for vans, SUVs, and pickups this year.

Car Horsepower, CID and Horsepower per CID

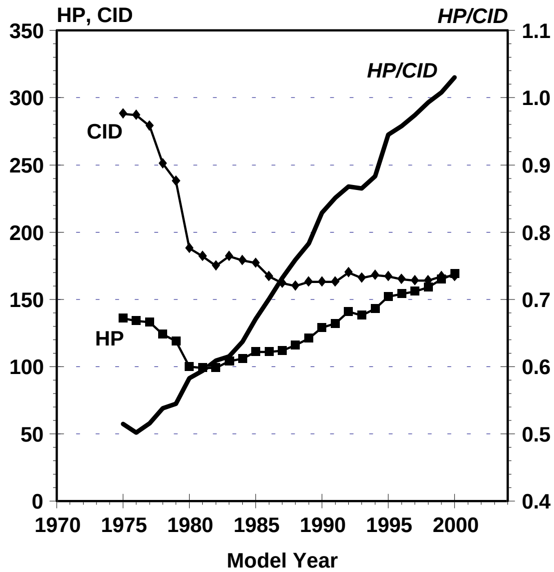

Figure 46

Van Horsepower, CID and Horsepower per CID

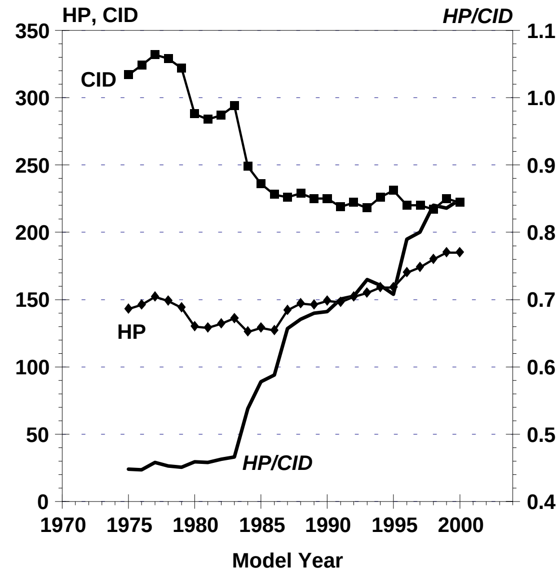

Figure 47

SUV Horsepower, CID and Horsepower per CID

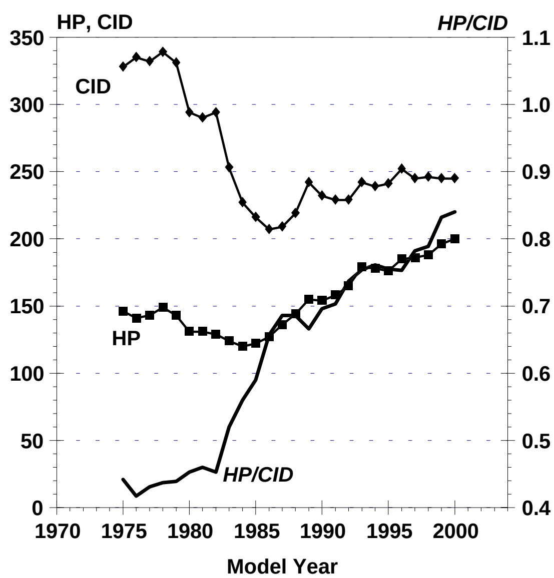

Figure 48

Pickup Horsepower, CID and Horsepower per CID

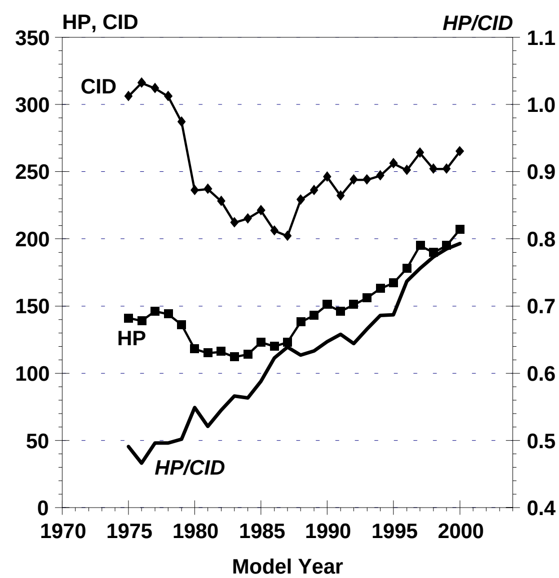

Figure 49

As shown in Table 11, for model year 2000 depending on the vehicle type, truck engines average about 10 to 20% more horsepower but require 33 to 60% greater displacement, compared to the average passenger car engine because of the differences in specific power.

Table 11 **MY2000 Engine Characteristics by Vehicle Type**

Vehicle Type	HP	CID	HP/ CID	Percent 4 Valve
Car	169	167	1.03	60%
Van	185	222	.85	20%
SUV	200	245	.84	25%
Pickup	207	265	.79	11%

Figures 50 to 53 show cubic-inch displacement (CID) by number of cylinders for cars, vans, SUVs, and pickup trucks. For all four vehicle types, displacement of eight-cylinder engines decreased in the late 1970's. For example, eight-cylinder car engine CID decreased about 20% between 1975 and 1985, i.e., from 376 to 296 CID. Similarly, six-cylinder car engines decreased from 225 CID in 1975 to 200 in 1986 and 192 this year. Conversely, four-cylinder passenger engine displacement increased from 112 CID in 1975 to 120 CID in 1985 and to 124 CID this year. The trend in CID for four- and six-cylinder engines used in vans is very similar to that for cars. In both cases, CID for six-cylinder engines has decreased while that for four-cylinder engines has increased from a nominal 110 CID to about 125 CID.

The CID trend for six-cylinder engines used in SUVs and pickups shows a significant decrease in the early 1980's when comparatively small (i.e., 3-liter) V-6 engines achieved a relatively high sales fraction. Since then, CID for six-cylinder engines used in both vehicle types has increased but is still below what it was in the late 1970's. Four-cylinder engines used in pickups show an increasing trend in CID similar to that for cars.

Figures 54 to 57 indicate that horsepower has increased substantially for four-, six-, and eight-cylinder engines for all four vehicle types. As shown in Table 12, eight-cylinder car

Displacement by Number of Cylinders Cars

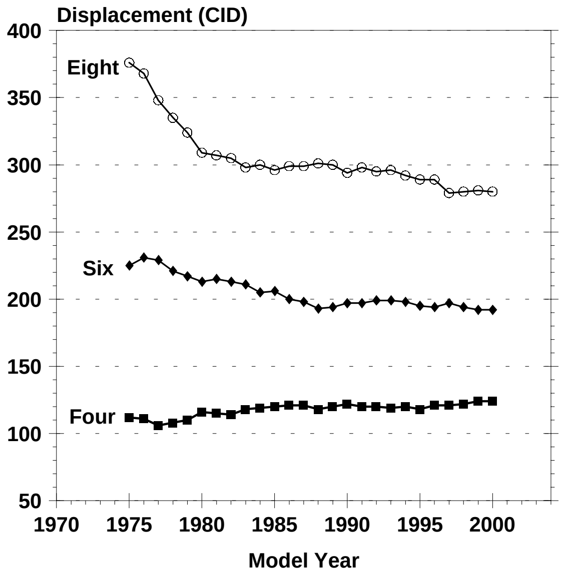

Figure 50

Displacement by Number of Cylinders Vans

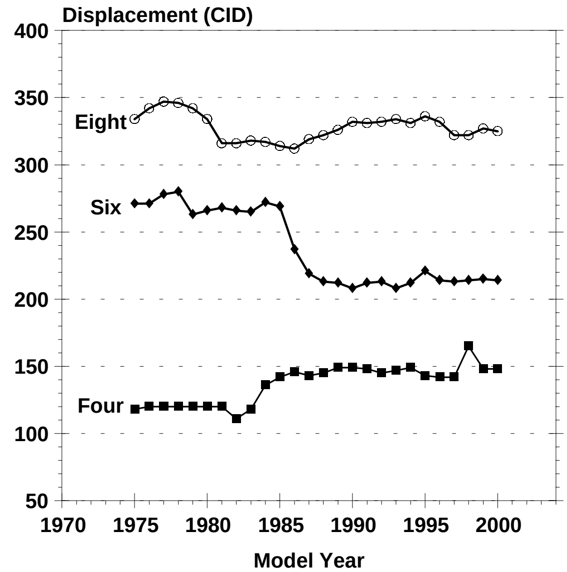

Figure 51

Displacement by Number of Cylinders SUVs

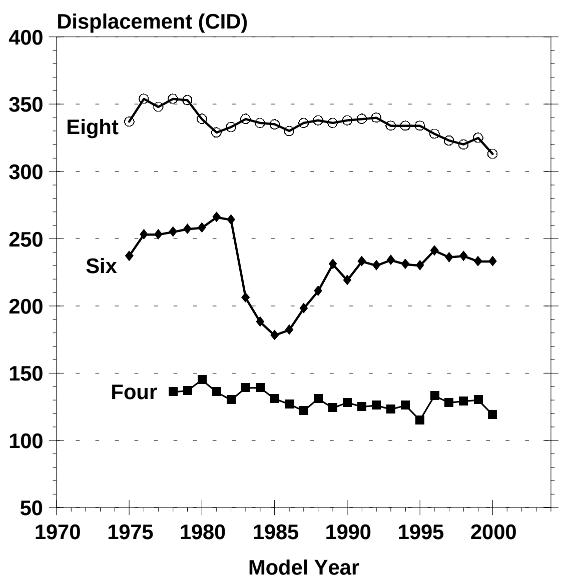

Figure 52

Displacement by Number of Cylinders Pickups

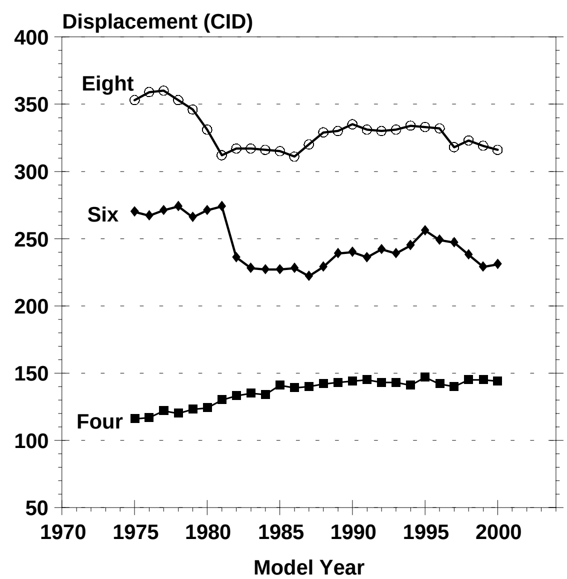

Figure 53

Horsepower by Number of Cylinders
Cars

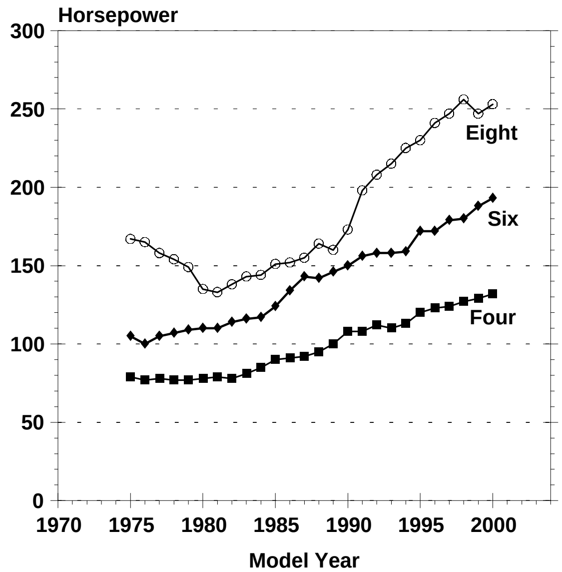

Figure 54

Horsepower by Number of Cylinders
Vans

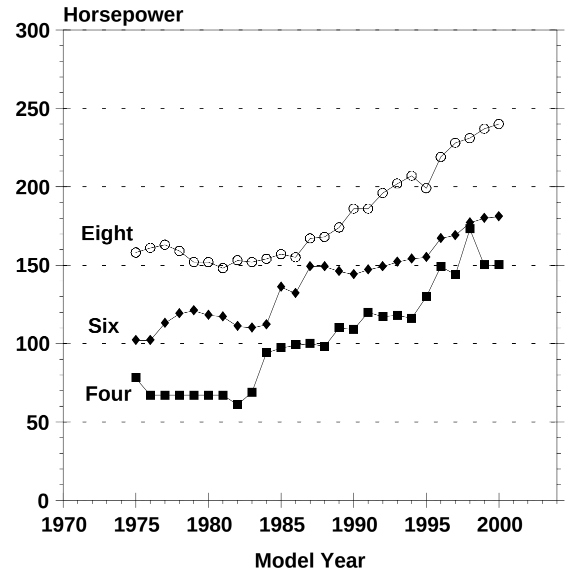

Figure 55

Horsepower by Number of Cylinders
SUVs

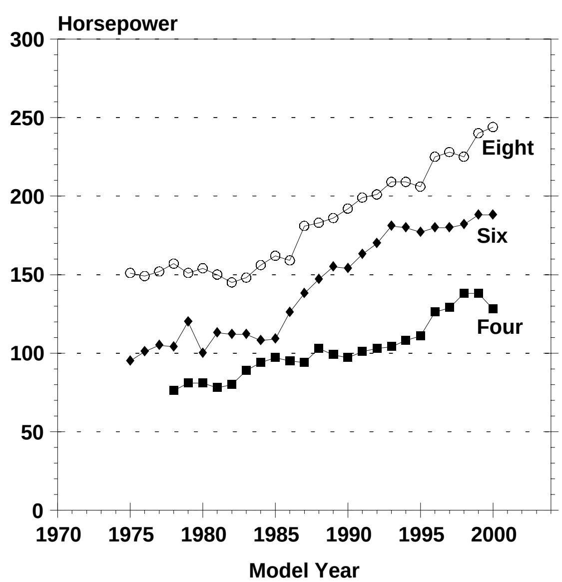

Figure 56

Horsepower by Number of Cylinders
Pickups

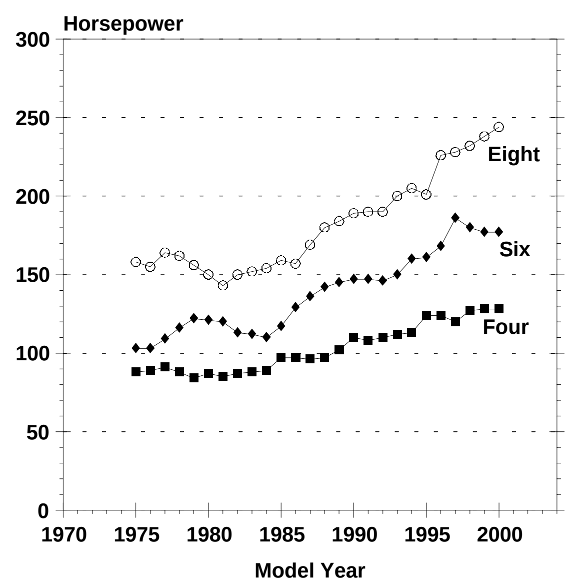

Figure 57

engines, for example, now attain 253 HP, compared to 164 HP in 1988. This represents an increase of over 50%. For all vehicle types, four-cylinder engines have higher horsepower this year than the equivalent six-cylinder engines did through the 1980's. Similarly, in all four cases, this year's six-cylinder engines have higher horsepower than comparable eight-cylinder engines through the late 1980's.

Table 12 compares CID, HP, and HP/CID by vehicle type and number of cylinders for model years 1988 and 2000. Since 1988, changes in engine size have been relatively small for all strata shown in the table, particularly when compared to the changes in horsepower that have taken place with specific power improvements related to the use of port fuel injection and multivalve engines accounting for the difference. Four-cylinder engines used in cars, vans, and SUVs have exceeded the one HP per CID level for several years, but the same cannot be said of pickup trucks.

At the number-of-cylinders level of stratification, model year 2000 cars achieve higher specific power than SUVs, vans, and pickup trucks with one minor exception: four-cylinder SUVs. Similarly, this year's pickup truck engines achieve lower specific power than their counterparts used in vans, SUVs, and cars.

Table 12 **Improvement in Horsepower and Specific Power by Vehicle Type and Number of Cylinders**

Vehicle Type	Cyl.	CID 1988	CID 2000	Percent Change	HP 1988	HP 2000	Percent Change	HP/CID 1988	HP/CID 2000	Percent Change
Car	4	118	124	5%	95	132	39%	.805	1.071	33%
	6	193	192	-1%	142	192	35%	.744	1.018	37%
	8	301	280	-7%	164	253	54%	.544	.907	67%
Van	4	145	148	2%	98	150	53%	.678	1.014	50%
	6	213	214	0%	149	181	21%	.722	.856	19%
	8	322	325	1%	168	240	43%	.520	.742	43%
SUV	4	122	130	7%	94	138	47%	.773	1.073	39%
	6	211	233	10%	147	188	28%	.706	.819	16%
	8	338	313	-7%	183	244	33%	.541	.783	45%
Pickup	4	142	144	1%	97	128	32%	.685	.894	31%
	6	229	231	1%	142	177	25%	.644	.772	20%
	8	329	316	-4%	180	244	36%	.544	.775	42%

Figures 58 to 61 compare sales fractions by four-, six- and eight-cylinder engines for cars, vans, SUVs, and pickup trucks. For purposes of this analysis, two-, three-, five-, ten-, and twelve-cylinder car engines are combined into a category labeled ‘other.’ Even on a combined basis, these ‘other’ engines have accounted for a very small percentage of the vehicles built each year since 1975.

The sales fraction for eight-cylinder engines has dropped for cars from nearly 60% in 1975, to about 20% in 1981, to about the 10% level in 1990 where it has remained. During the mid-1980's, similar decreases in eight-cylinder engine usage occurred for van, SUV, and pickup truck engines. Since then, eight-cylinder engine usage in vans continued to decrease, but increases have occurred for SUVs and pickups which have increased their usage of eight-cylinder engines from about 20% in 1987 to over 50% this year. In addition, four-cylinder engine usage in vans peaked at about 40% in 1985 but has dropped substantially since then.

The sales fraction of six-cylinder car engines remained within a relatively narrow range (i.e., about 18, plus or minus 2%) between 1975 and 1979. Since then, their sales fraction has more than doubled and is projected to be above 40% this year. From 1975 to 1992, a similar trend occurred for usage of six-cylinder engines in all three types of truck engines. Since then, however, usage of these engines has continued to increase for vans, but it has decreased for SUVs and pickups. Six-cylinder engines currently account for about a third, half, and a fourth, respectively, of this year’s vans, SUVs, and pickups.

Passenger car engines have high values of HP per CID, because not only is HP per CID improving, but also the fraction of higher specific-power engines is increasing. Figures 62 to 65 show HP/CID for engines with 2-, 3-, and 4-valve-per-cylinder cylinder-head configurations for cars, vans, SUVs, and pickups. Figures 66 to 69 show the market share by number of valves per cylinder by vehicle type.

The use of four valves per cylinder in passenger car engines grew rapidly between 1987 and 1995, but its rate of growth has been much slower since then. The market share of 4-valve-per-cylinder passenger car engines has been at about the 60% mark for the past three years. The introduction and use of four-valve engines for SUVs, vans, and pickup trucks has trailed that of cars in that order. Almost 90% of all pickup truck engines still have two valves per cylinder, as do about 80% of the vans and 70% of the SUVs compared to 35% of the cars.

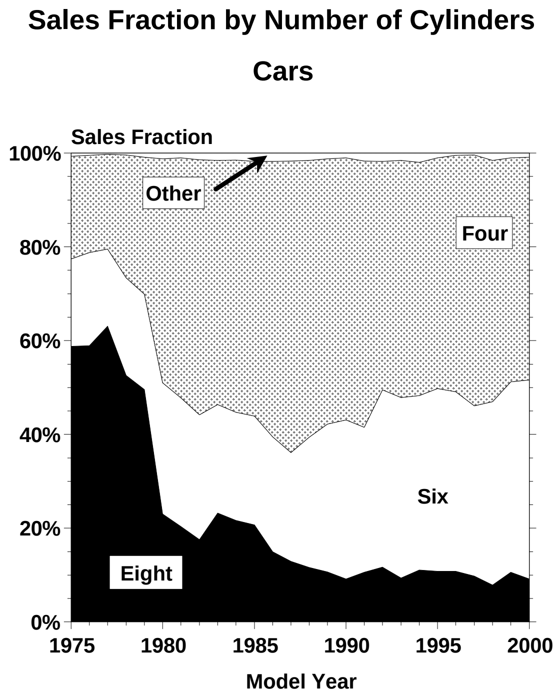

Figure 58

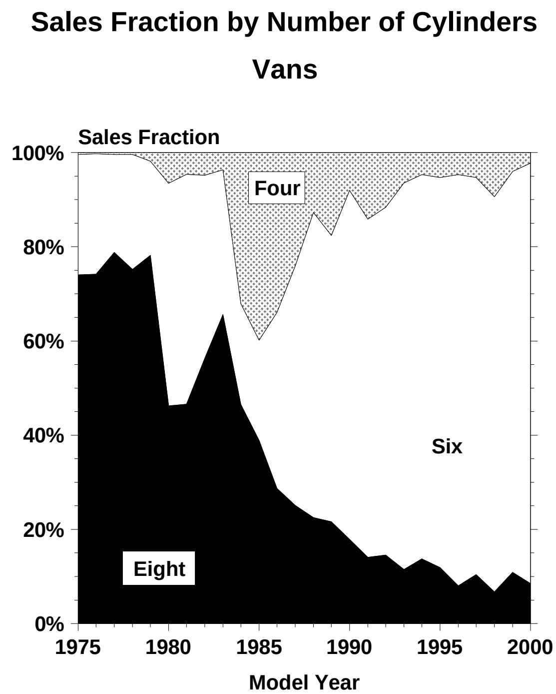

Figure 59

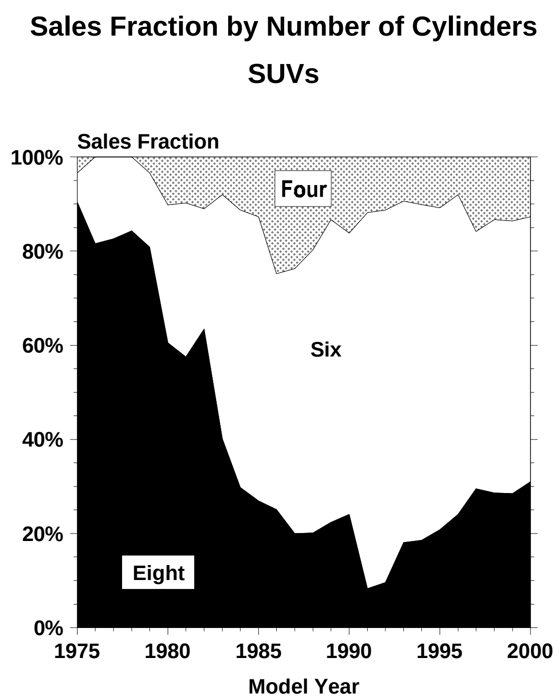

Figure 60

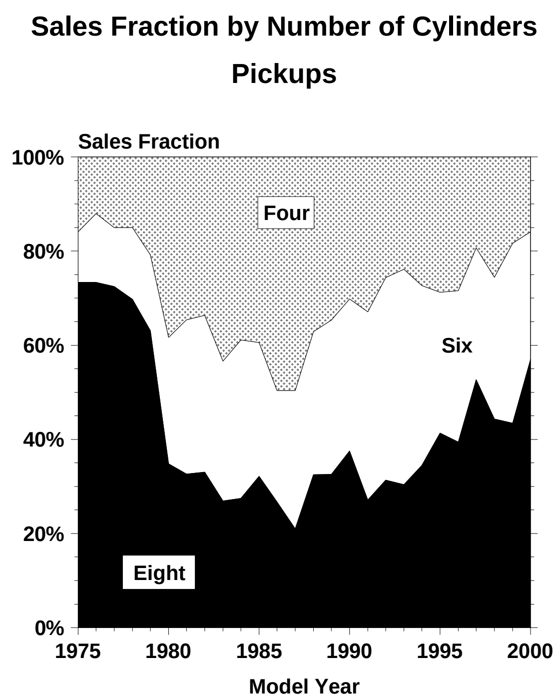

Figure 61

HP/CID by Number of Valves Per Cylinder

Cars

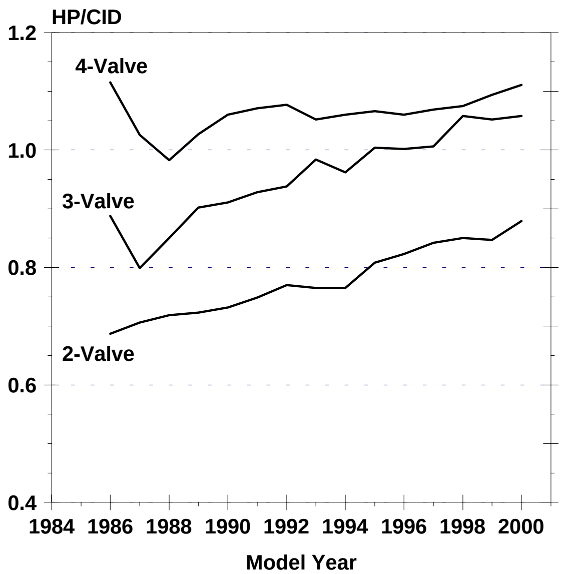

Figure 62

HP/CID by Number of Valves Per Cylinder

Vans

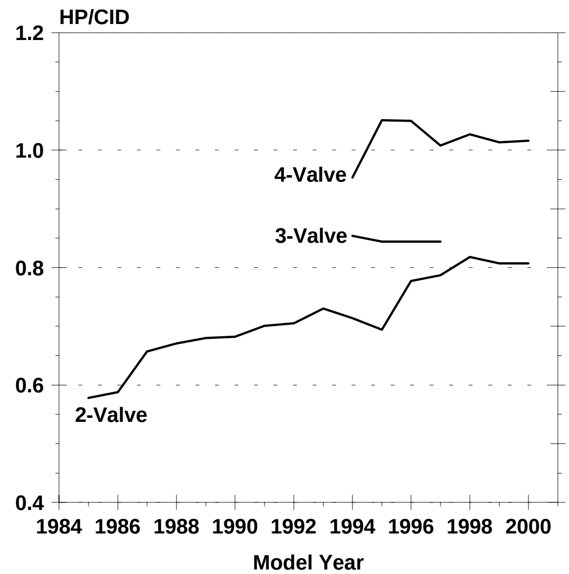

Figure 63

HP/CID by Number of Valves Per Cylinder

SUVs

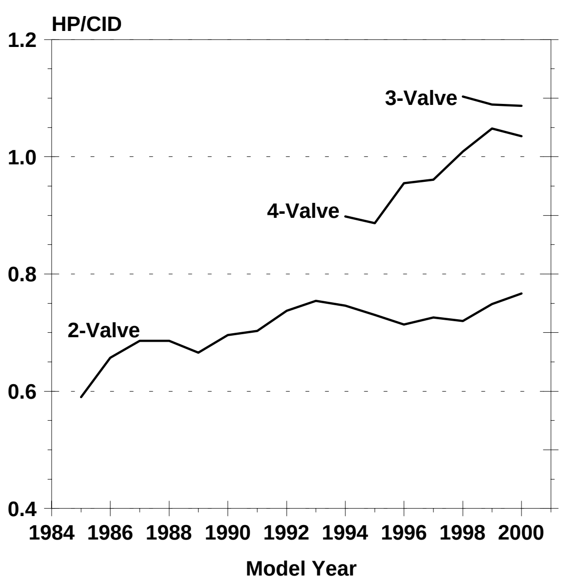

Figure 64

HP/CID by Number of Valves Per Cylinder

Pickups

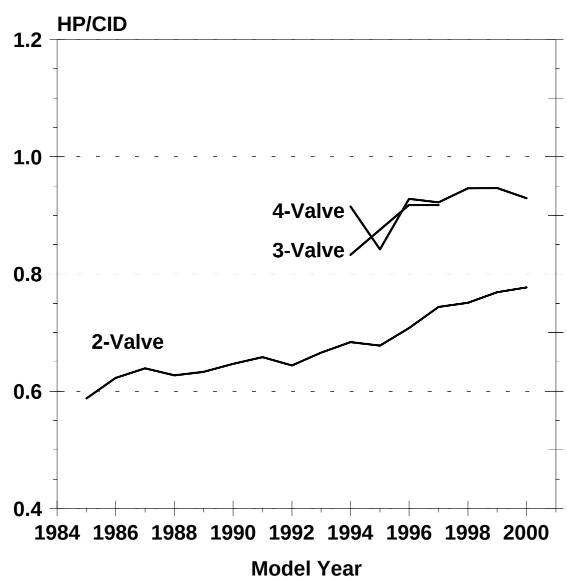

Figure 65

Number of Valves per Cylinder

Cars

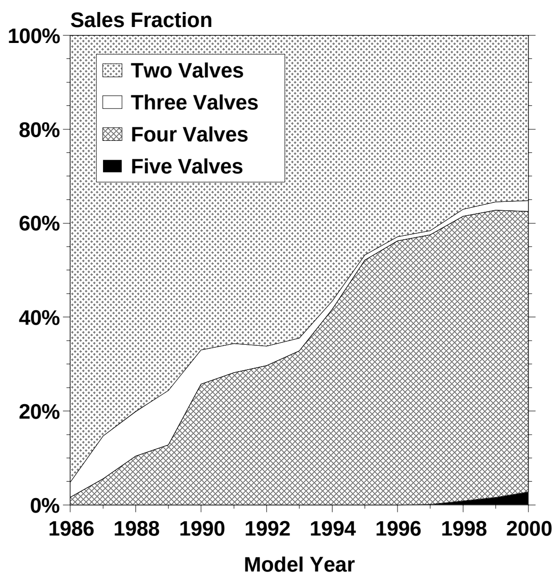

Figure 66

Number of Valves per Cylinder

Vans

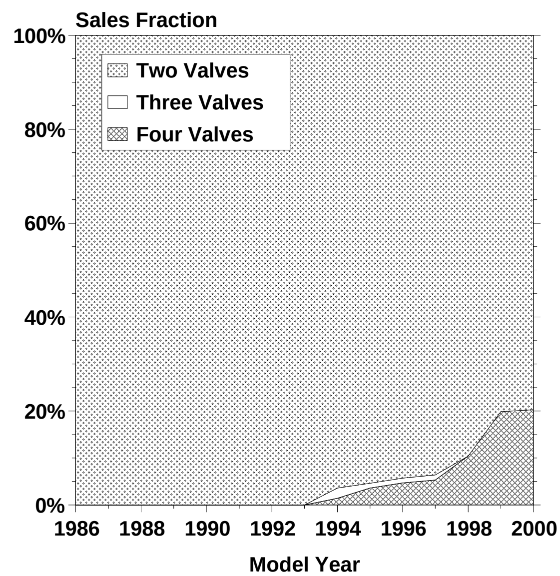

Figure 67

Number of Valves per Cylinder

SUVs

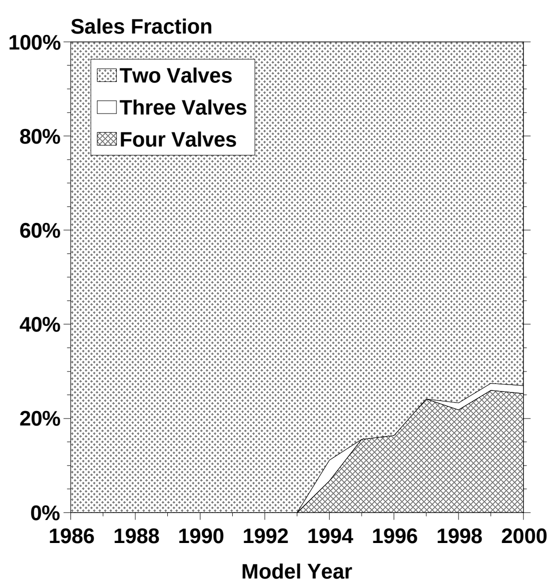

Figure 68

Number of Valves per Cylinder

Pickups

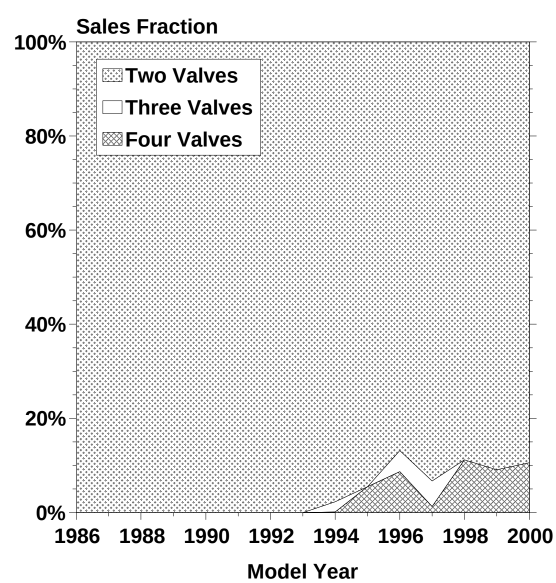

Figure 69

Figure 70 compares penetration rates for five passenger car technologies, namely port fuel injection (Port FI), front-wheel drive (FWD), four valves per cylinder (4-Valve) and four- and five-speed lockup transmissions (L4 and L5). This figure indicates that it may take a decade for a technology to prove itself and attain a sales fraction of 40 to 50% and as long as another five or ten years to reach maximum market penetration. With the recent introduction of the L5 transmission type, the sales fraction of L4 transmissions appears to have reached its maximum and started a declining trend.

A similar comparison of three technologies whose sales fraction peaked out at about 40% or less is shown in Figure 71. This figure shows that it may also take a number of years for technologies such as 3-valve-per-cylinder engines (3-valve) throttle body fuel injection (TBI), and lockup 3-speed (L3) transmissions to reach their maximum sales fraction, and even then use of these technologies may continue for a decade or longer.

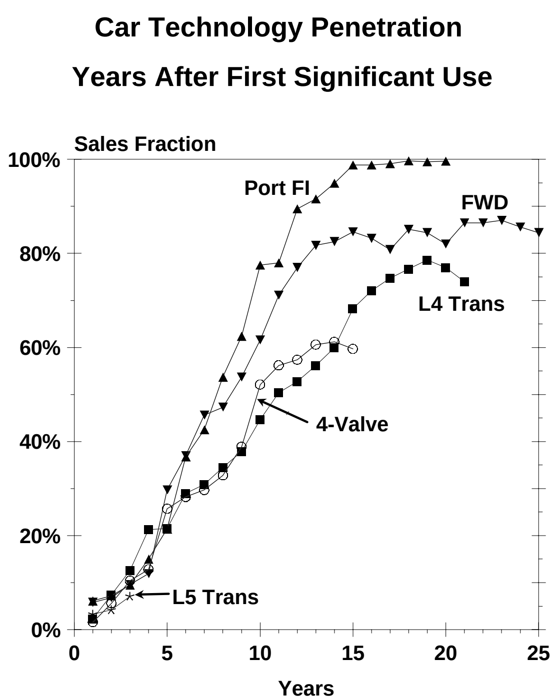

Figure 70

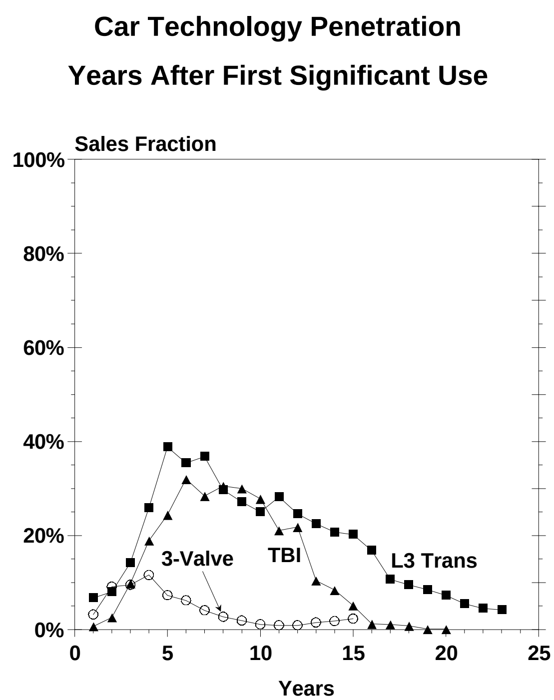

Figure 71

V. Trends by Market Segment

Figures 72 and 73 show that domestic trucks and Asian cars have achieved the largest growth in both sales and sales fraction since 1975 with much of this growth coming at the expense of domestic cars. Since 1975, the market share of domestic cars dropped by nearly 40%. In 1975, roughly two-thirds of all light-duty vehicles were domestic cars, compared to only a fourth this year. Half (see Table 13) of the decrease in domestic car sales fraction occurred between 1975 and 1988. For MY2000, the market shares of domestic trucks (i.e., vans, SUVs, and pickups combined) and also imported cars will both exceed that of domestic cars.

Table 13 **Sales Fraction of 1975, 1998, and 2000 Light-Duty Vehicles by Market Segment**

	Sales (000)			Market Share			Market Share Change From:		
Market Segment	1975	1988	2000	1975	1988	2000	1975 To 2000	1975 To 1988	1988 To 2000
Domestic Car	6718	6574	4263	.657	.430	.266	-.391	-.227	-.164
European Car	673	675	1204	.066	.044	.075	.009	-.022	.031
Asian Car	846	3487	3166	.083	.228	.198	.115	.145	-.030
All Cars	8237	10736	8633	.806	.702	.539	-.267	-.104	-.163
Domestic Van	455	1077	1128	.045	.070	.070	.026	.026	.000
Imported Van	2	55	342	.000	.004	.021	.021	.003	.018
All Vans	457	1132	1470	.045	.074	.092	.047	.029	.018
Domestic SUV	181	729	2209	.018	.048	.138	.120	.030	.090
Imported SUV	6	239	1012	.001	.016	.063	.063	.015	.048
All SUVs	187	968	3221	.018	.063	.201	.183	.045	.138
Domestic Pickup	1126	1889	2358	.110	.124	.147	.037	.013	.024
Imported Pickup	216	569	331	.021	.037	.021	.000	.016	-.017
All Pickups	1342	2458	2689	.131	.161	.168	.037	.029	.007
All Domestic Trucks	1762	3695	5695	.172	.242	.356	.183	.069	.114
All Imported Trucks	224	863	1685	.022	.056	.105	.083	.035	.049
All Trucks	1986	4558	7380	.194	.298	.461	.267	.104	.163
All Cars & Trucks	10223	15294	16013						

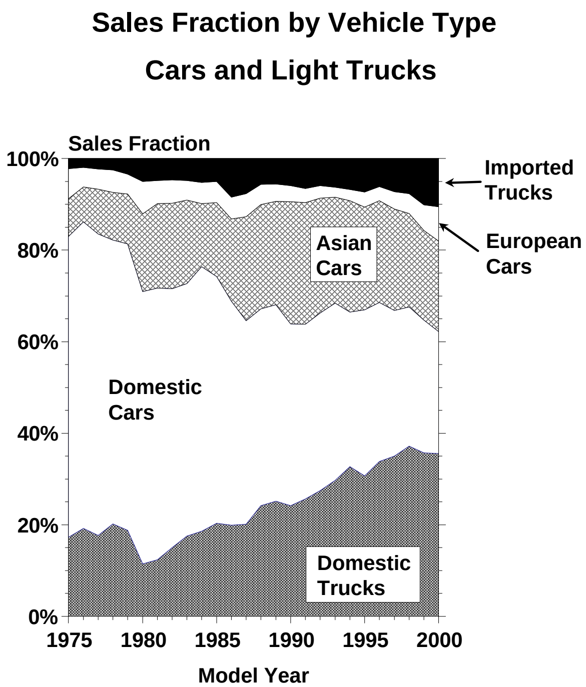

Figure 72

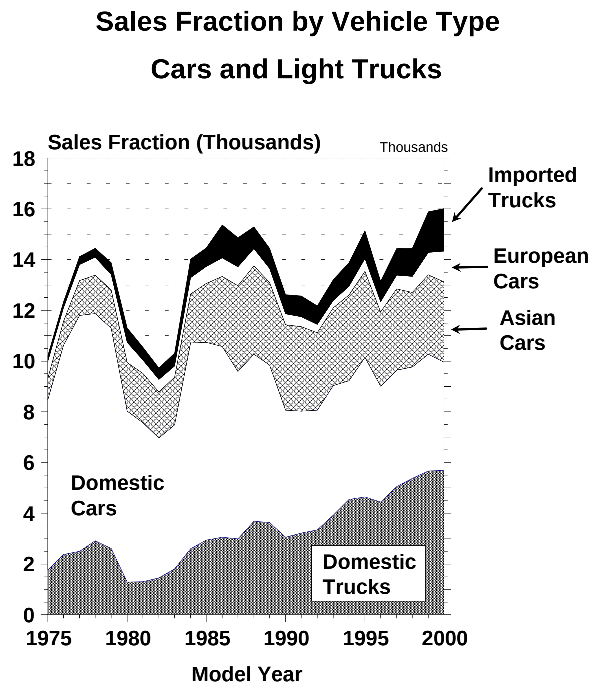

Figure 73

Figure 74 compares the relative sales fractions of domestic pickups, vans, SUVs, and cars. From 1975 to 1981, cars accounted for about 75 to 80% of the domestic vehicles, but their relative market share has been below 50% for the past four years. Vans, which accounted for about 5% of the domestic vehicles in 1975, reached a peak relative market share of about 14% in 1995 and have dropped slightly since then. The relative market share for domestic pickups has increased from about 13% in 1975 to nearly 25% the past two years. SUVs have experienced the largest increase in market share among domestic vehicles, and their sales fraction is now ten times what it was in 1975.

Conversely, Figure 75 shows that cars still account for nearly three-fourths of this year's imported vehicles compared to nearly 90% of 1975's. The relative sales fraction for imported pickups has decreased by over half from about 12% in 1975 to about 5% this year, while imported vans and SUVs have increased their relative sale fractions from a minuscule amount in 1975 to about 6% and 17%, respectively, this year.

Sales Fraction by Vehicle Type: Domestic Vehicles

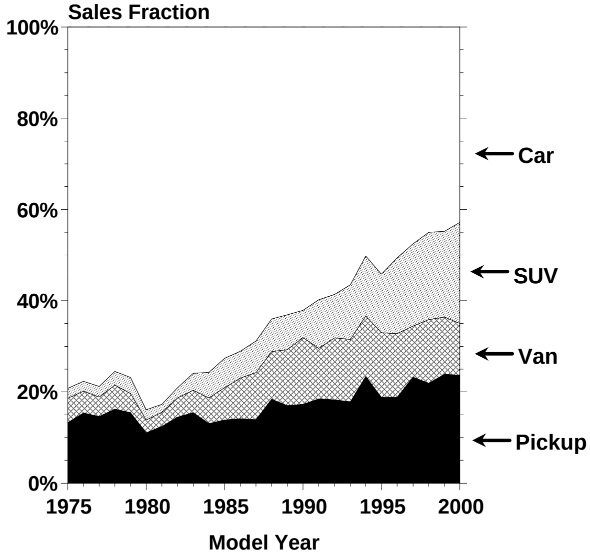

Figure 74

Sales Fraction by Vehicle Type: Imported Vehicles

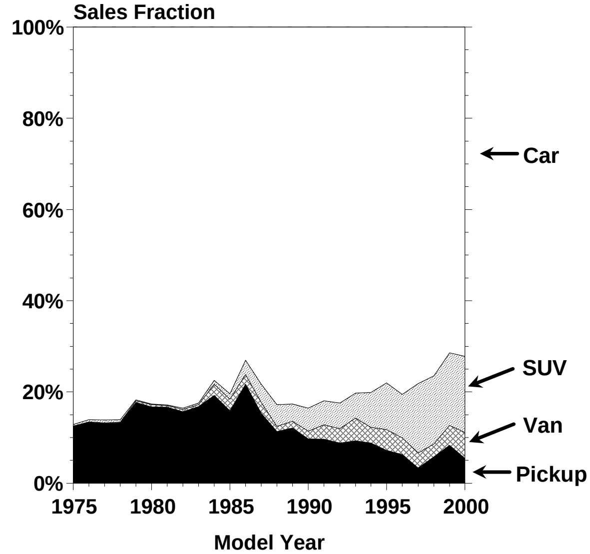

Figure 75

Figure 76 compares average mpg for domestic, European, and Asian cars. Similar data for domestic and imported vans, SUVs, and pickup trucks is shown in Figures 77 to 79. Asian cars have always had higher mpg than their domestic counterparts. Through 1985, European cars had higher mpg than domestic ones. Since 1986, however, domestics have achieved higher mpg than European cars. Average car mpg for all three of these car segments has changed very little since 1990, particularly when compared to the changes which occurred in the late 1970's and early 1980's. For example, Table 14 shows domestic car mpg increased over 12 mpg between 1975 and 1988 but has stayed between 26.6 and 27.4 mpg since then.

Fuel economy of European cars increased by 6 mpg between 1975 and 1981 when over a third of them had diesel engines and over two-thirds used manual transmissions. By 1988, European car use of diesel engines had dropped below 1%, and their manual transmission usage decreased by over 25%. Since 1988, European car fuel economy has ranged from 24.6 to 26.7 mpg. Asian cars have always had higher fuel economy than their domestic and European counterparts. Their fuel economy peaked at 32.9 mpg in 1986 and has remained at about 30 mpg since 1990.

Car MPG

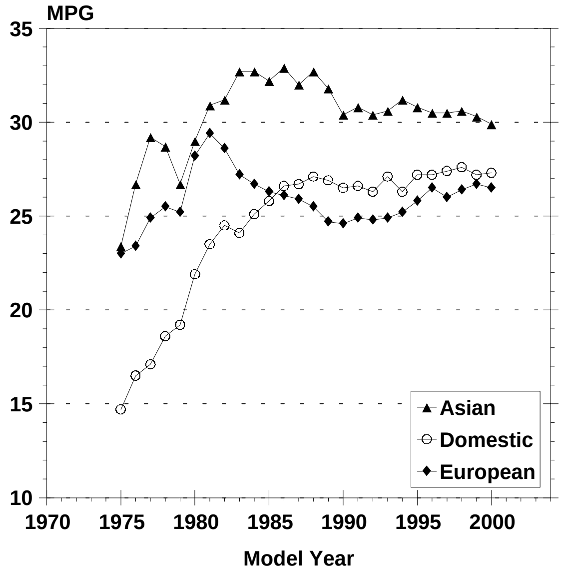

Figure 76

Van MPG

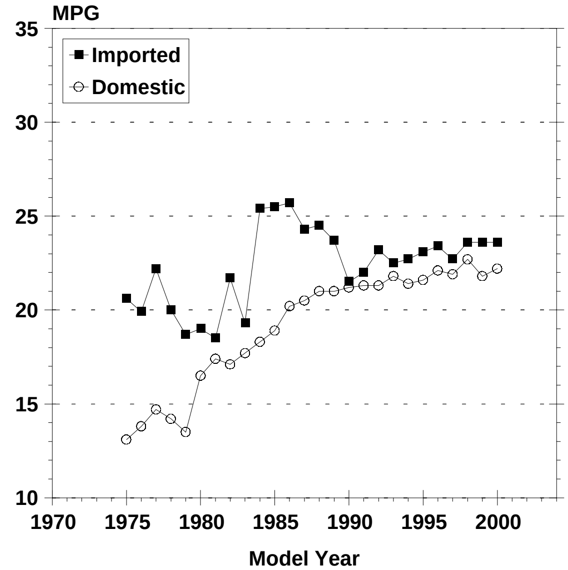

Figure 77

SUV MPG

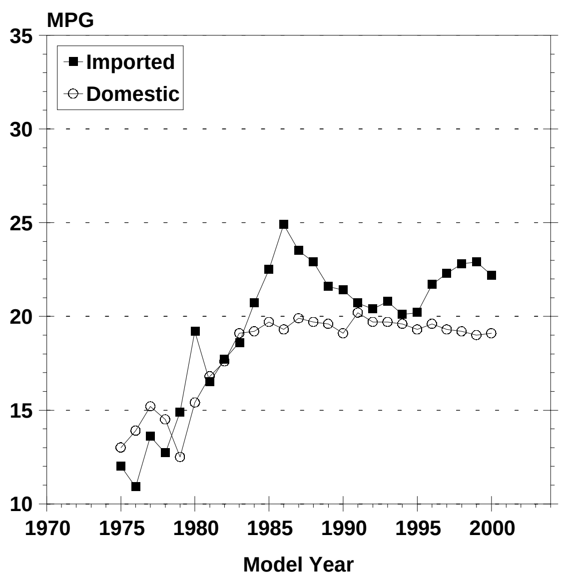

Figure 78

Pickup MPG

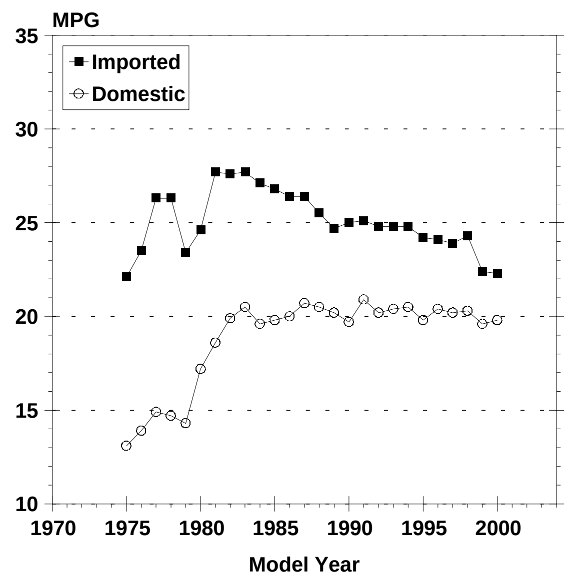

Figure 79

Table 14 **Fuel Economy of MY1975, MY1988, and MY2000 Light-Duty Vehicles by Market Segment**

Market Segment	Average Mpg			Percent Change From:		
	1975	1988	2000	1975 To 2000	1975 To 1988	1988 To 2000
Domestic Car	14.7	27.1	27.3	85.7%	84.4%	0.7%
European Car	23.0	25.5	26.5	15.2%	10.9%	3.9%
Asian Car	23.4	32.7	29.9	27.8%	39.7%	-8.6%
All Cars	15.8	28.6	28.1	77.8%	81.0%	-1.7%
Domestic Van	13.1	21.0	22.2	69.5%	61.8%	10.5%
Imported Van	20.6	24.5	23.6	14.6%	18.9%	-3.7%
All Vans	13.1	21.2	22.5	71.8%	61.8%	6.1%
Domestic SUV	13.0	19.7	19.1	46.9%	51.5%	-3.0%
Imported SUV	12.0	22.9	22.2	85.0%	90.8%	-3.1%
All SUVs	13.0	20.4	20.0	53.8%	56.9%	-2.0%
Domestic Pickup	13.1	20.5	19.8	51.1%	56.5%	-3.4%
Imported Pickup	22.1	25.5	22.3	.9%	15.4%	-12.5%
All Pickups	14.0	21.5	20.1	43.6%	53.6%	-6.5%
Domestic Truck	13.1	20.5	19.9	51.9%	56.5%	-2.9%
Imported Truck	21.6	24.7	22.5	4.2%	14.4%	-8.9%
All Trucks	13.7	21.2	20.5	49.6%	54.7%	-3.3%
All Cars & Trucks	15.3	25.9	24.0	56.9%	69.3%	-7.3%

The fuel economy trends for domestic vans, SUVs, and pickups are similar to that for domestic cars with fuel economy for all three of these market segments improving by 50 to 60% between 1975 and 1988 and changing relatively little since then. Since 1988, domestic vans have ranged from 21.0 to 22.7 mpg, domestic SUVs from 19.0 to 20.2 mpg, and domestic pickups from 19.6 to 20.9 mpg. Domestic vans, SUVs, and pickups have always had lower fuel economy than their imported counterparts. Imported vans, SUVs, and pickups all increased their fuel economy between 1975 and the mid 1980's but are lower now than they were then.

Car and Light Truck MPG

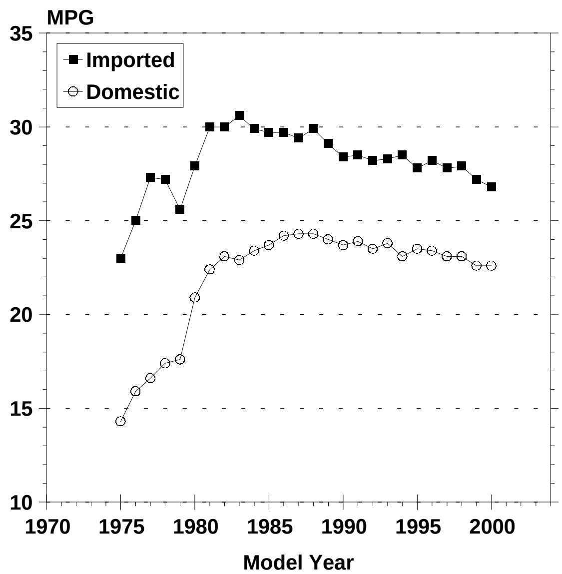

Figure 80

Car Interior Volume

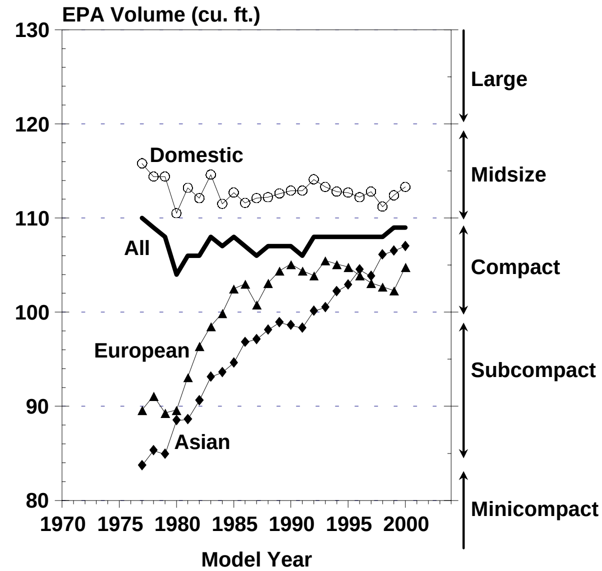

Figure 81

As shown in Figure 80, the gap between imported and domestic combined car and truck mpg has remained at about 5 or 6 mpg, compared to a much larger difference in 1974. On a combined car and truck basis, fuel economy for both domestic and imported vehicles has been declining since the mid-1980's.

Figure 81 compares interior volume for domestic, European, and Asian cars. Through 1980, interior volume for European cars remained below 90 cu. ft.; between then and 1989, it increased over 16% to about 105 cu. ft. where it has essentially remained. Asian cars, with just a couple of minor exceptions, have increased their interior volume every year since 1978. By comparison, domestic car interior volume has been relatively stable, as has the overall average for all passenger cars.

Vehicle performance, as measured by estimated 0-to-60 acceleration time, has changed at remarkably consistent rates for domestic, European, and Asian cars and also for both domestic and imported vans, pickups, and SUVs (see Figures 82 to 85). There is one exception: through 1983, imported vans had 0-to-60 times above 20 seconds compared to a nominal 15 seconds for the other vehicle types. This exception can be considered minor because a *combined* total of less than 75,000 imported vans were sold for all years between 1975 and 1983.

Car 0 to 60 Time

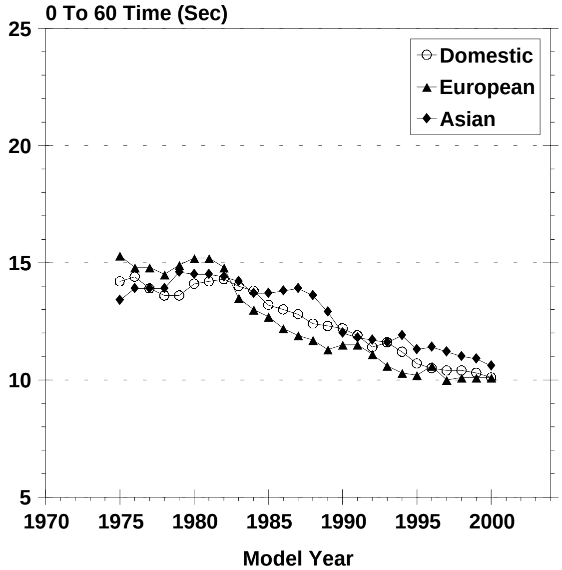

Figure 82

Van 0 to 60 Time

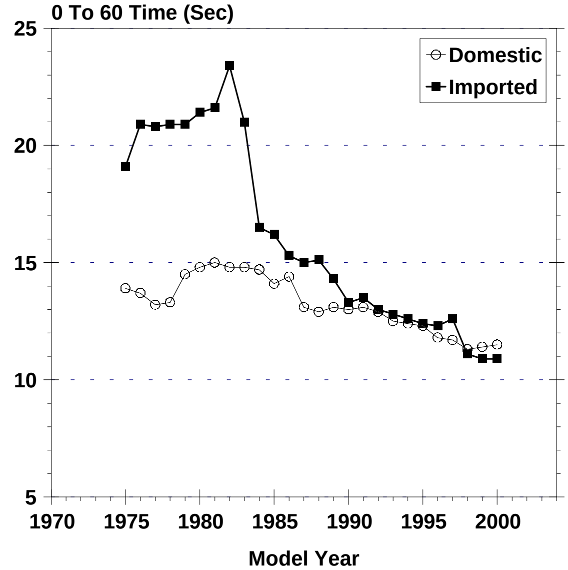

Figure 83

SUV 0 to 60 Time

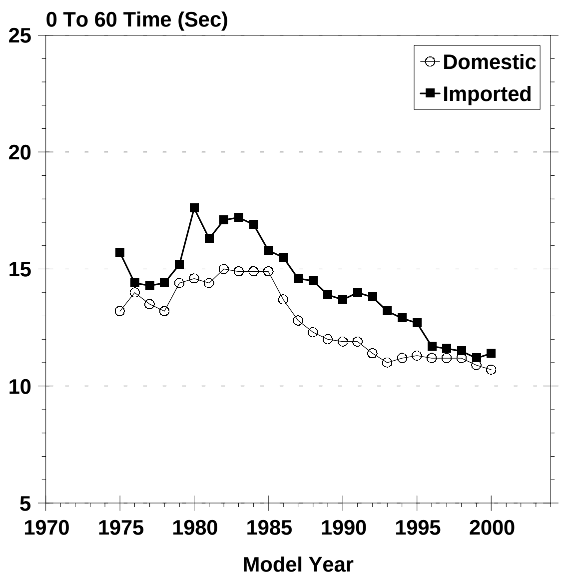

Figure 84

Pickup 0 to 60 Time

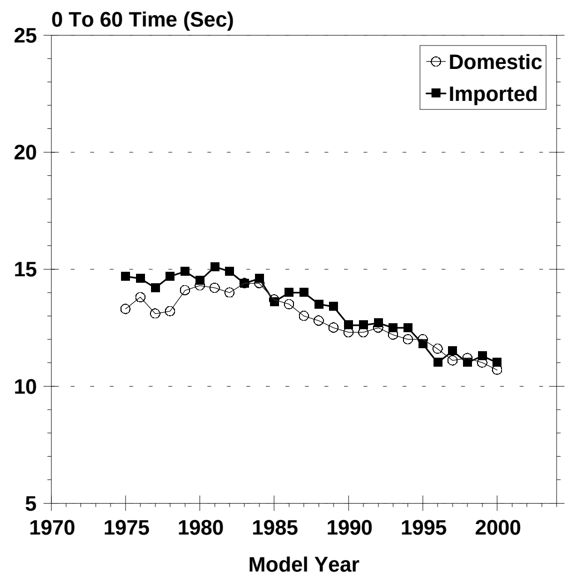

Figure 85

Car Inertia Weight

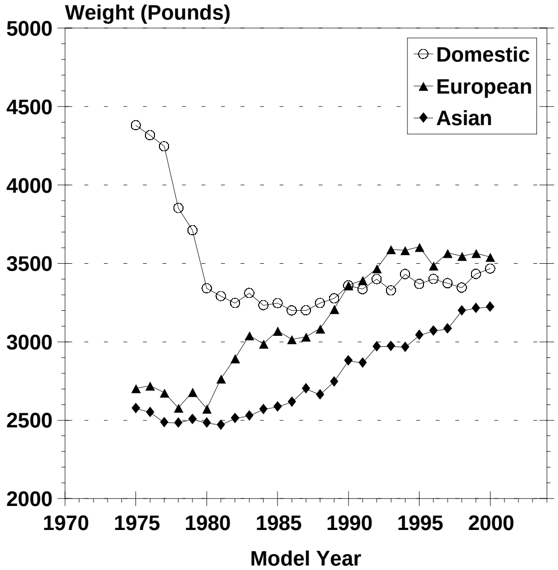

Figure 86

Van Inertia Weight

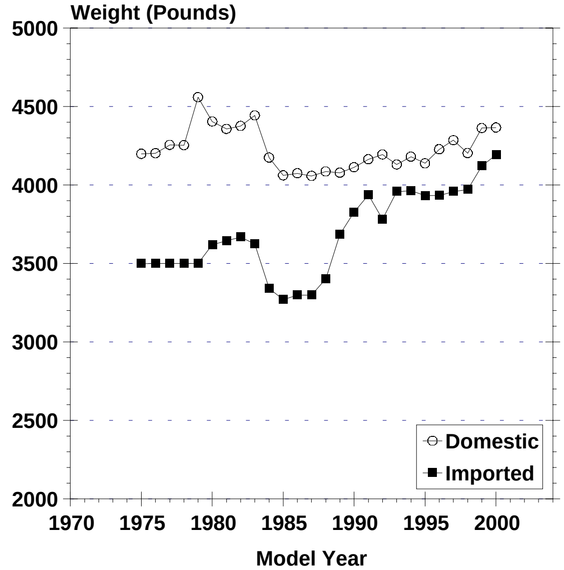

Figure 87

SUV Inertia Weight

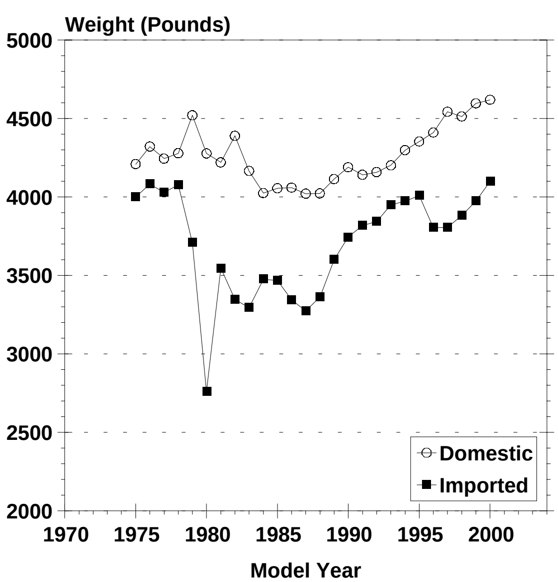

Figure 88

Pickup Inertia Weight

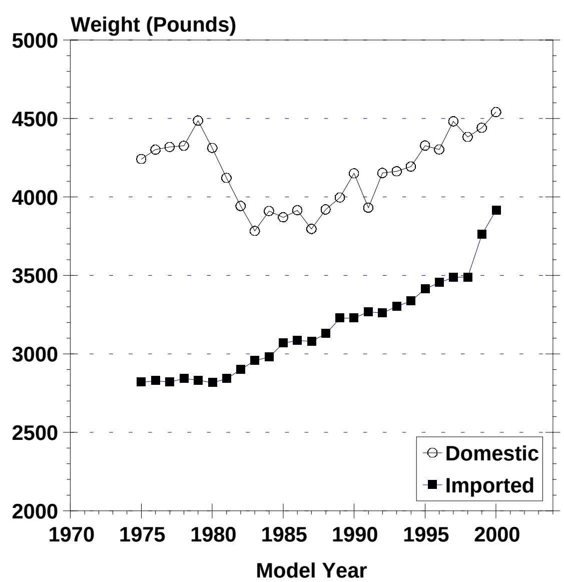

Figure 89

Figures 86 to 89 and Table 15 compare inertia weight for the same market segments as the preceding figures. Inertia weight for domestic, European, and Asian cars has now converged. In 1975, domestic cars were more that 1800 pounds lighter than Asian ones. Inertia weight for domestic cars dropped over a thousand pounds between 1975 and 1984 but has increased by about 200 pounds since then. Conversely, inertia weight of European cars increased by over 350 pounds (i.e., from about 2700 to 3070 pounds) between 1975 and 1985 and by about another 500 pounds since then. Inertia weight for Asian cars remained at a nominal 2500 pounds through the early 1980's but has since increased to over 3200 pounds.

Inertia weight for domestic vans has remained between a nominal 4100 to 4400 pounds, but inertia weight for imported vans which once were nearly 700 to 800 pounds lighter than domestic vans has increased, so that the two segments differ in inertia weight by less than 200 pounds. Domestic and imported SUVs and pickups all have increased their inertia weight, particularly since the mid 1980's, but the domestics continue to be 500 to 600 pounds heavier than their imported counterparts.

The trend toward increasing ton-mpg, discussed earlier, persists for all of the market segments shown in Figures 90 to 93. Domestic, European, and Asian cars not only have had similar ton-mpg trends but also the same approximate ton-mpg values over a relatively long period of time. The same observations apply to domestic and imported vans, SUVs, and pickups.

Table 15 **Inertia Weight of Light-Duty Vehicles by Market Segment for Six Model Years**

	Model Year					
Market Segment	1975	1980	1985	1990	1995	2000
Domestic Car	4380	3341	3246	3359	3368	3466
European Car	2704	2574	3070	3360	3605	3541
Asian Car	2575	2482	2585	2879	3041	3221
Domestic Van	4189	4404	4061	4113	4138	4366
Imported Van	3498	3618	3270	3826	3932	4192
Domestic SUV	4209	4277	4055	4189	4353	4619
Imported SUV	4000	2760	3468	3744	4008	4099
Domestic Pickup	4241	4312	3870	4150	4327	4540
Imported Pickup	2819	2817	3067	3228	3415	3915

Car Ton-MPG

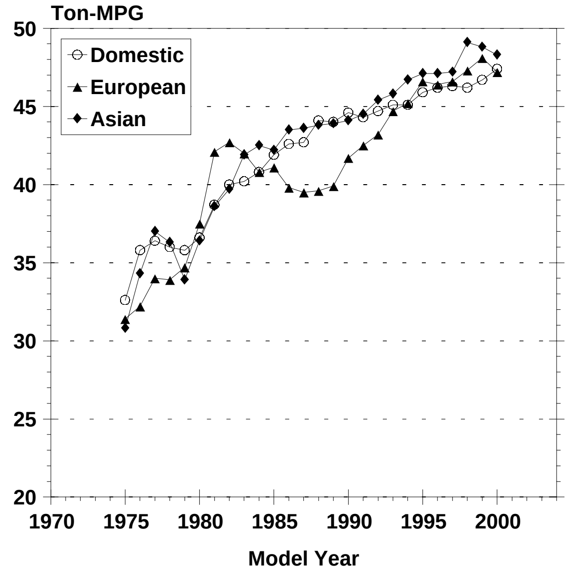

Figure 90

Van Ton-MPG

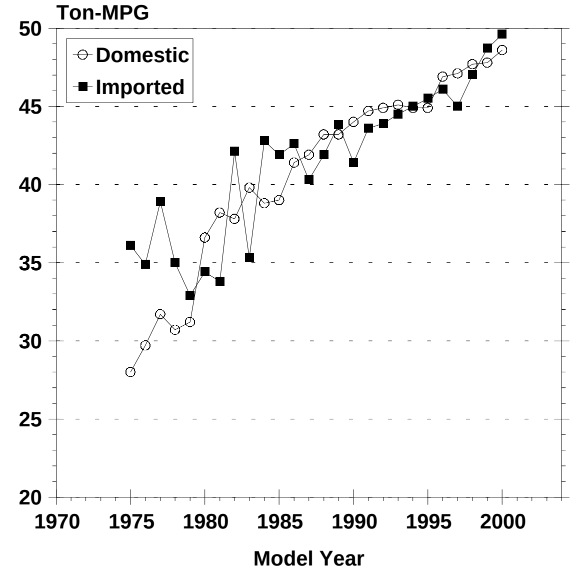

Figure 91

SUV Ton-MPG

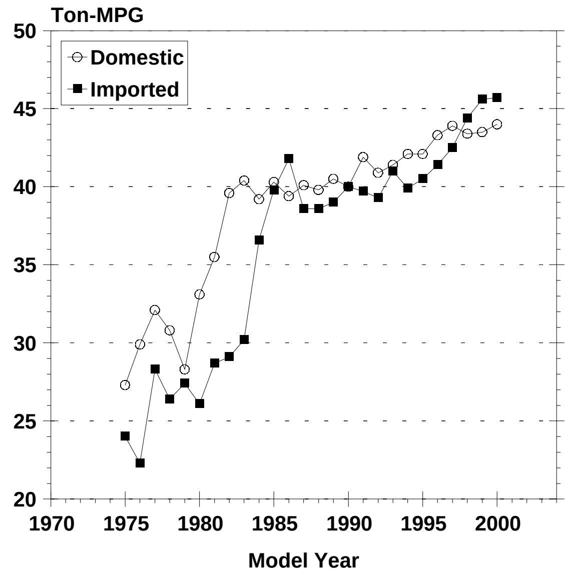

Figure 92

Pickup Ton-MPG

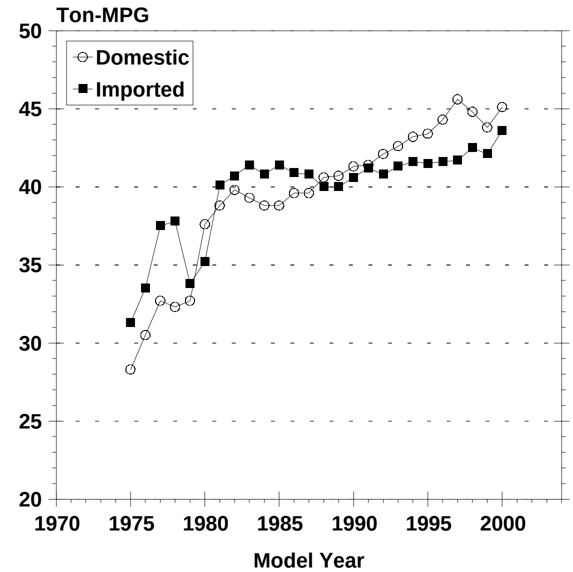

Figure 93

Car Specific Power

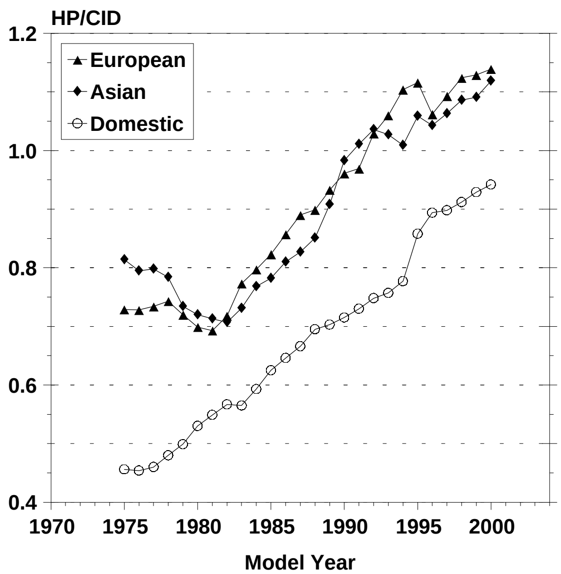

Figure 94

Van Specific Power

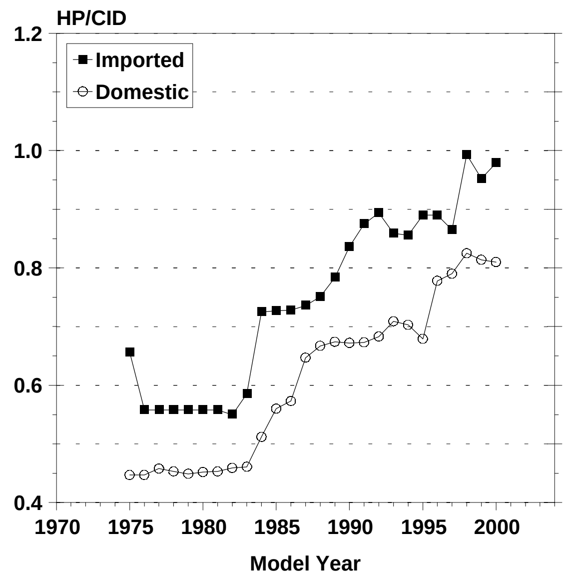

Figure 95

SUV Specific Power

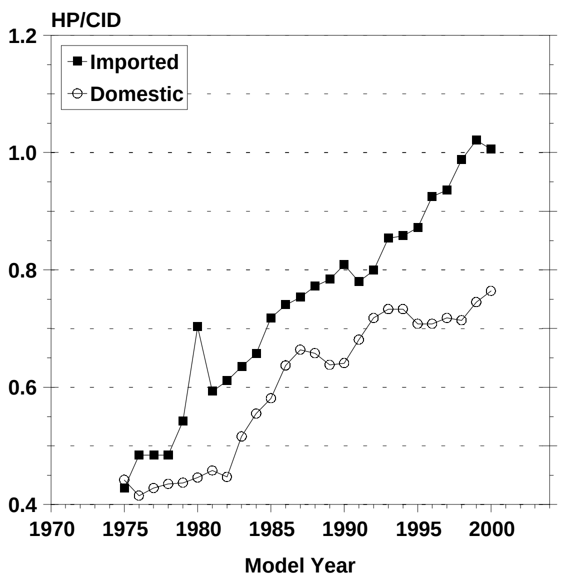

Figure 96

Pickup Specific Power

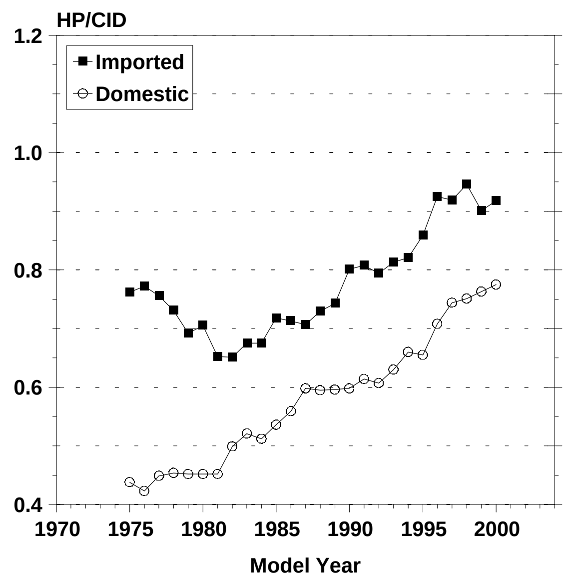

Figure 97

The trend toward higher specific power (HP/CID), also discussed earlier, persists for the market segments shown in Figures 94 to 97. The improvement of specific power for domestic vehicles has always trailed that of their import counterparts by about a decade. European and Asian cars now achieve more than 1.1 HP/CID compared to .94 for the domestics. Similarly, imported SUVs will achieve more than 1.0 HP/CID this year compared to less than 0.8 for the domestics. Imported vans currently have higher specific power than domestic cars, but specific power for domestic cars exceeds that for imported pickups.

Table 16 compares technology usage for MY2000 for domestic, European, and Asian cars and domestic and imported vans, SUVs, and pickups. The trend noted above towards higher specific power for European and Asian cars and imported trucks is consistent with their greater use of four-valve-per-cylinder engines than the domestics. About 90% of domestic and Asian cars use front-wheel drive compared to about half of the European ones. European and Asian cars make greater use of manual transmissions than their domestic counterparts, as do imported SUVs and pickups.

Table 16 **Technical Characteristics of MY 2000 Light-Duty Vehicles By Market Segment**

	<--- Engine --->			<- Percent of vehicles with: ->			
Market Segment	HP	CID	HP/CID	Four Valve	Front Drive	4 Wheel Drive	Manual Trans
Domestic Car	176	190	.942	34%	86%	0%	9%
European Car	184	162	1.139	50%	54%	10%	23%
Asian Car	155	138	1.119	98%	94%	4%	17%
Domestic Van	184	230	.810	3%	68%	5%	0%
Imported Van	188	193	.979	78%	100%	0%	0%
Domestic SUV	211	277	.764	2%	0%	74%	5%
Imported SUV	173	176	1.006	76%	5%	67%	18%
Domestic Pickup	212	276	.775	0%	0%	37%	17%
Imported Pickup	173	190	.918	86%	0%	39%	49%

VI. Fuel Economy Improvement

As previously discussed (see Table 1 and Figure 1), the fuel economy of the combined car and truck fleet has been declining for the past dozen years, despite the fact that both car and light-truck fuel economy, when considered separately, have been relatively stable. Since 1988, vehicle attributes such as acceleration performance, weight, and utility have been much higher consumer priorities than fuel economy. Because fuel prices have been increasing and because of increasing scientific concern over global warming, interest in improving fuel economy has been increasing. Accordingly, it is relevant to “mine” what potential exists for improving fuel economy. There are, of course, a number of different hypothetical approaches that can be used to do this. Several basic ones are used in this report.

One simple approach is to consider recent public commitments by individual vehicle manufacturers as indicative of what could be achieved by the fleet as a whole. For example, Ford Motor Company recently announced their intention to improve the average fuel economy of its SUVs by 25% by model year 2005. For model year 2000, Ford’s SUVs are estimated to average about 18 mpg. Ford has also stated that about 70% of their improvement in fuel economy will come from technology such as more efficient powertrains (i.e., engines and transmissions), aerodynamics, and weight reductions, and that about 30% of the improvement will come from sales of smaller vehicles such as the Escape which is scheduled to be introduced in model year 2001. Ford thus needs to increase the fuel economy of its SUVs by slightly less than five mpg (i.e., to about 23 mpg) by 2005 to meet its stated fuel economy improvement objective.

Similarly, General Motors has stated that their light trucks currently average about 4% higher fuel economy than Ford’s, and they have stated that they intend to remain the leader in light truck fuel economy in five years. For model year 2000, General Motors’ SUVs are estimated to average roughly 19 mpg. For General Motors to have higher average fuel economy than Ford in the SUV market segment, their SUVs, by 2005, will have to average slightly more than 23 mpg.

General Motors and Ford account for slightly less than half of this year’s SUVs. If both of these manufacturers increase their average SUV fuel economy by at least 25%, it is possible their competitors will match the fuel economy improvements made by Ford and General Motors and similarly increase their SUV fuel economy by 25%.

Effect if Fuel Economy is Improved 25% by 2005

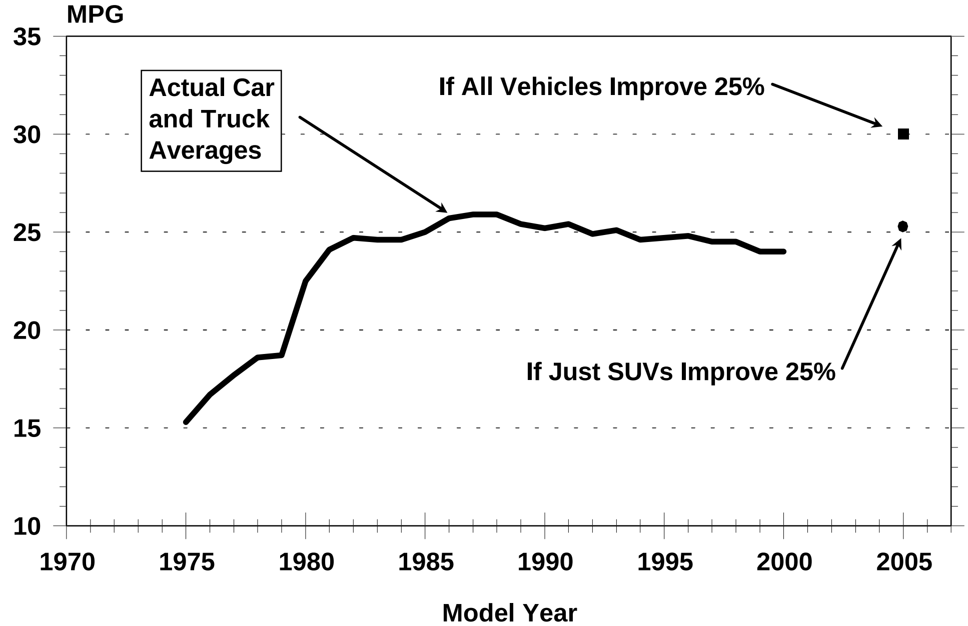

Figure 98

Figure 98 compares average fuel economy for both cars and trucks for 1975 to 2000 with two projections. The first of these projections shows the light-duty vehicle fuel economy average that could be attained by model year 2005 if:

(1) there was a 25% increase in average fuel economy of all SUVs less than 8500 lb. GVW, and

(2) no other changes in sales fraction or fuel economy for the other light-duty vehicle types occur.

Under this scenario, passenger car fuel economy would remain the same; SUV fuel economy would increase from 20.0 to 25.0 mpg; light truck fuel economy would increase by 10% from 20.5 to 22.5 mpg; and average fuel economy of both cars and trucks would improve about 5% from 24.0 to 25.2 mpg. Such a fleet would have the same average fuel economy as was most recently achieved in 1993, but still would be 0.7 mpg less than the maximum of 25.9 mpg achieved in 1987 and 1988.

The second scenario in Figure 98 shows what could happen if all light-duty vehicle manufacturers voluntarily increased the average fuel economy of all of their light vehicles (i.e., all of their cars, vans, SUVs, and pickups) by 25% by 2005. Under this scenario, cars would average 35.1 mpg, trucks 25.6, and both cars and trucks 30.0. This scenario, like the first one, considers just vehicles under 8500 GVW and assumes the sales fraction for all vehicle types remains unchanged. While all of these fuel economy values are higher than any achieved between 1975 and this year, the objective of improving fuel economy by 25% in five years is substantially less than what has been achieved previously. For example, between 1975 and 1980 the fuel economy of cars increased by nearly 50% and that of trucks by about 35%.

A second approach for determining what potential exists for improving fuel economy is “best in class” analysis which involves dividing the fleet of vehicles into classes, selecting a set of representative “role model” vehicles from each class, and then calculating the average characteristics of the resultant fleet using the same relative sales proportions as in the baseline fleet.

In the discussion which follows, four best-in-class analyses are made using four different procedures to select the role models. Three of these selection procedures use the EPA Car Size Classes (which for cars are the same as those used for the EPA/DOE Fuel Economy Guide) and the truck type/size classes described previously in this report. Note that this classification system includes nine car and nine truck classes and, for model year 2000, two of these eighteen classes are not represented (Large Wagons and Small Vans). The fourth best-in-class role model selection procedure is based on using the vehicle inertia weight classes used for EPA’s emission certification process.

The advantage of using and analyzing data from the best-in-size class methods is that if the sales proportions of each class are held constant, the sales distribution of the resultant fleet by *vehicle type and size* does not change. Similarly, there also is an advantage in using the inertia weight classes to determine the role models, since if the sales proportions in each inertia weight class are held constant, the sales distribution of the resultant fleet by *weight* does not change.

One relatively simple way of selecting the role models uses an historic approach and involves an analysis of all vehicles produced between 1975 and 2000. This method involves determining for each of the truck size classes (see Appendix E) and EPA Car Size Classes (see Appendix F) which model year had the highest fuel economy and then using as role models all of the vehicles in each such size class. For example, as shown in Table 17, the highest fuel economy for Two-Seaters was achieved in 1991 when they averaged 29.0 mpg, or 3.9 mpg more than this year's Two-Seaters, so all 1991 Two-Seaters are used as role models as are all of the 1985 Minicompacts, etc.

The relative sales proportions of each class were then adjusted so that each role model retained its original sale fraction within its class, but the sales fractions for each class were proportioned to be the same as for the current model year.

Table 17 **"Best" Fuel Economy by Model Year and Vehicle Size Class**

	"Best" Year's Data			Actual MY2000 Data		
Vehicle Size Class	Model Year	Sales (000s)	55/45 MPG	Sales (000s)	55/45 MPG	Difference In 55/45 MPG
Two Seater	1991	178	29.0	125	25.1	3.9
Minicompact	1985	73	36.0	44	24.0	12.0
Subcompact	1996	1108	32.9	1345	30.8	2.1
Compact	1998	2119	30.9	2370	30.4	0.5
Midsize	1998	2970	27.1	2775	27.1	0.0
Large	2000	1648	25.4	1648	25.4	0.0
Small Wagon	1995	198	33.3	94	28.5	4.8
Midsize Wagon	2000	231	27.4	231	27.4	0.0
Large Wagon	1996	9	23.2	---	----	---
Small Van	1993	12	28.2	---	----	---
Midsize Van	2000	1264	23.4	1264	23.4	0.0
Large Van	1997	139	18.6	207	18.2	0.4
Small SUV	1996	120	28.5	376	23.5	5.0
Midsize SUV	1999	1793	20.9	1967	20.8	0.1
Large SUV	1982	22	18.9	878	17.3	1.6
Small Pickup	1981	369	28.2	248	23.7	4.5
Midsize Pickup	1977	66	29.5	677	22.7	6.8
Large Pickup	2000	1764	18.9	1764	18.9	0.0

Table 18 compares the results for two different best historic class scenarios: one in which the actual sales vector for each of the role models is retained and one in which the sales matrix is adjusted to match the MY2000 sales. In both cases, there is some, but very limited, mpg improvement potential. Using the best year's actual data results in a combined car and truck average of 25.1 mpg, using the MY2000 sales matrix results in a combined average of 24.8 mpg, compared to an actual average of 24.0 mpg.

These relatively small increases in mpg can be attributed in part to the fact that four of the 16 active classes achieved their highest mpg this year. There are five cases (Minicompacts, Small Wagons, Small SUVs, Small Pickups, and Midsize Pickups) where there was a relatively large difference (i.e., 4.5 or more mpg) between this year's fuel economy and the highest ever attained by the class. The total sales for these five classes for MY2000, however, is less than 9% of this year's total sales.

It is also interesting to note that, with four exceptions, the peak mpg year occurred fairly recently, i.e., since 1992. One of these exceptions involves Minicompacts, a size class that has traditionally had very low sales. The peak years for two of the others (model year 1981 Small Pickups and model year 1982 Large SUVs) were ones for which a relatively large number of

Table 18 **Results of "Best" Fuel Economy by Model Year and Vehicle Size Class Analysis**

		Total Sales (000s)	Sales Fraction	55/45 MPG
Best Year's Data	Cars	8534	.606	28.5
	Trucks	5540	.394	21.2
	Both	14083		25.1
Actual MY2000 Data	Cars	8632	.539	28.1
	Trucks	7381	.461	20.5
	Both	16013		24.0
Combine Best Year's Mpg and MY2000 Sales Mix	Cars	8632	.539	28.6
	Trucks	7381	.461	21.5
	Both	16013		24.8

diesel engines were used in each class; and the fourth exception (model year 1977 Midsize Pickups) was for a year in which a large percentage of the vehicles used manual transmissions.

Appendix B of this report includes a list sorted by fuel economy of the vehicle name plates for model year 2000 by vehicle type and size. A second way of performing a best-in-class analysis is to use as role models the four nameplates with the highest fuel economy in each size class. Under this procedure, all vehicles in a class with the same nameplate are included as role models regardless of vehicle configuration. Each role model nameplate from each class was assigned the same sales weighting factor, but the original sales weighting distribution for different vehicle configurations within a given nameplate (e.g., transmission type, engine size, and/or drive type) was retained. The resulting values were used to recalculate the fleet average values using the same relative proportions in each of the size classes that constitute the fleet.

In cases where two identical vehicles differ by only one characteristic, but have slightly different nameplates (such as the two-wheel drive Chevrolet C1500 and the four-wheel drive K1500 pickups), both are considered to have the same nameplate. Conversely, in the cases where technically identical vehicles with different nameplates are used (e.g., the Chevrolet S10 Pickup, GMC Sonoma, and Isuzu Hombre or the Suzuki Swift and Chevrolet Metro), only one representative vehicle nameplate was used.

The third best-in-class role model selection procedure involves selecting as role models the best dozen vehicles in each size class with each vehicle configuration considered separately. Tables L-1 and L-2 in Appendix L give listings of the representative vehicles used in this method. As with the previous procedure, in cases where technically identical vehicles have different nameplates, only one representative vehicle was used. Under this best-in-class method, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to re-calculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

The fourth best-in-class procedure involves selecting as role models the best dozen vehicles in each weight class. As with the previous method, each vehicle configuration was considered separately. (See Tables L-3 and L-4 for listings of the MY2000 vehicles used in this analysis.) It should be noted that some of the weight classes have less than a dozen representative vehicles. In addition, as in the previous two best-in-class methods, where technically identical vehicles with different nameplates are used, only one representative vehicle was included. As with the two best-in-size class methods, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to recalculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

Tables 19 and 20 compare, for cars and trucks respectively, the results of the best-in-class (BIC) analysis with actual average data for model year 2000. Note that for the Size Class scenarios, the percentage of vehicles that are small, midsize, or large are the same as for the fleet as a whole, and in the Weight Class scenarios, the average weight of the BIC data sets is the same as the actual one. Despite the fact that 55% of the cars in the BIC weight class data set are classified as “Small,” compared to 45% in the entire fleet, average interior volume for cars in the BIC weight class analysis is only slightly smaller than the overall average (109 vs. 106 cu. ft.). The small differences in interior volume between the Size Class scenarios and the actual

Table 19 **Best in Class Results**
Model Year 2000 Cars

Selection Basis	Actual Data	Size Class	Size Class	Weight Class
Selection Criteria	All Cars	Best 4 Nameplates	Best 12 Vehicles	Best 12 Vehicles
55/45 Mpg	28.1	31.4	33.2	31.1
Weight	3386	3070	3091	3386
Volume	109	107	108	106
0 to 60 Time	10.3	10.8	11.2	11.2
CID	167	137	132	135
HP	170	143	138	149
HP/CID	1.03	1.06	1.05	1.11
% Four Valve	60%	77%	71%	69%
% Front Drive	84%	98%	98%	85%
% Four Wheel Drive	3%	1%	1%	3%
% Manual	14%	23%	53%	51%
% Small	46%	46%	46%	55%
% Midsize	35%	35%	35%	43%
% Large	19%	19%	19%	2%
% Domestic	49%	29%	37%	26%

fleet can be attributed to the fact that, within a size class, there is considerable variation in interior volume (i.e., not all vehicles in each size class have the same interior volume.)

Under all of the best-in-class (BIC) scenarios, the vehicles used for the BIC analysis have less powerful engines, have slower 0-to-60 acceleration times, are less likely to be domestic, and are more likely to be equipped with manual transmissions than the entire fleet as a whole. Usage of front- and four-wheel drive is about the same for cars in the BIC weight class analysis but not in the size class where there is about 14% greater use of front-wheel drive than in the actual fleet. For trucks, however, the BIC data set vehicles make greater use of front-wheel drive. When the best 12 vehicles in size or weight were used as the role model selection criteria, the truck BIC data sets also make significantly less use of four-wheel drive than the actual fleet.

For both cars and trucks, the “Best 12 Vehicles” in Size Class scenario results in significantly higher fuel economy than the actual fleet, but the vehicles in these BIC sets are considerably lighter than their counterparts from the other

Table 20 **Best in Class Results**
Model Year 2000 Trucks

Selection Basis	Actual Data	Size Class	Size Class	Weight Class
Selection Criteria	All Trucks	Best 4 Nameplates	Best 12 Vehicles	Best 12 Vehicles
55/45 Mpg	20.5	21.6	22.9	22.2
Weight	4432	4252	4036	4432
0 to 60 Time	11.0	10.9	11.3	11.8
CID	248	220	203	218
HP	200	193	176	183
HP/CID	.83	.92	.89	.87
% Four Valve	19%	49%	40%	37%
% Front Drive	16%	22%	23%	28%
% Four Wheel Drive	46%	46%	15%	27%
% Manual	12%	12%	38%	31%
% Small	8%	8%	8%	12%
% Midsize	53%	53%	53%	57%
% Large	39%	39%	39%	31%
% Domestic	77%	47%	58%	65%

scenarios. Depending on the scenario chosen, for model year 2000, cars could have achieved from 11 to 18% better fuel economy than they did. Similarly, trucks could have achieved from 5 to 10% better fuel economy

The best-in-class analysis indicates significant fuel economy improvement potential, but it should be pointed out that in all three of the best-in-class scenarios, cars have a substantially higher fraction of manual transmission installation than in today’s fleet. Similarly, trucks have a higher manual transmission sales fraction for two of the three best-in-class truck scenarios. The best-in-class analysis thus provides an indication of what could happen if more efficient transmissions, such as the five speed lockup (L5) or possibly continuously variable transmissions (CVTs), become cost effective to produce and widely accepted.

A third approach for determining potential fuel economy improvement is to consider the fuel economy improvements that could have been achieved, had new, more efficient technologies been used to improve fuel economy, rather than to improve acceleration performance and to increase vehicle weight. This approach involves studying the trade-offs that have been made between fuel economy, vehicle size or weight, and 0-to-60 acceleration time.

One way to improve fuel economy is to reduce vehicle weight. Figures 99 and 100 show changes in the sales fraction for cars and trucks that have occurred since 1975. In 1975, about half of the cars had inertia weights above 4000 pounds, compared to only a few percent since 1980. Since 1980, the sales fraction of several of the lighter inertia weight classes have increased considerably, the 3500-pound class in particular. The trend for trucks is somewhat different, particularly since the late 1980's where there has been a shift from the lighter (i.e., 3500 pounds and below) inertia weight classes to the heavier ones.

The relationship between weight and fuel economy for model year 1975 and model year 2000 cars and trucks is shown in Figures 101 and 102, respectively. In all four cases, vehicles with lighter weight have higher fuel economy (see Appendix G). The difference between the two lines on each of these graphs shows the improvement in fuel economy at constant weight that has occurred since 1975. For example, in 1975 cars in the 3000 lb. inertia weight class averaged 21.4 mpg compared to 30.3 mpg this year with improvements in vehicle technology accounting for much of the difference.

Sales Fraction by Inertia Weight Class
Cars

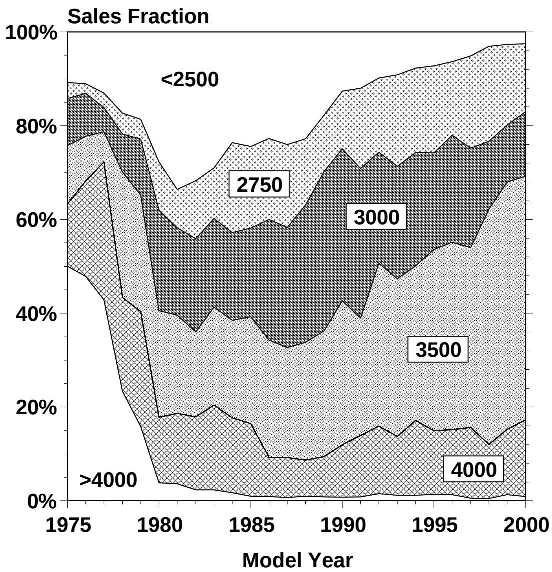

Figure 99

Sales Fraction by Inertia Weight Class
Trucks

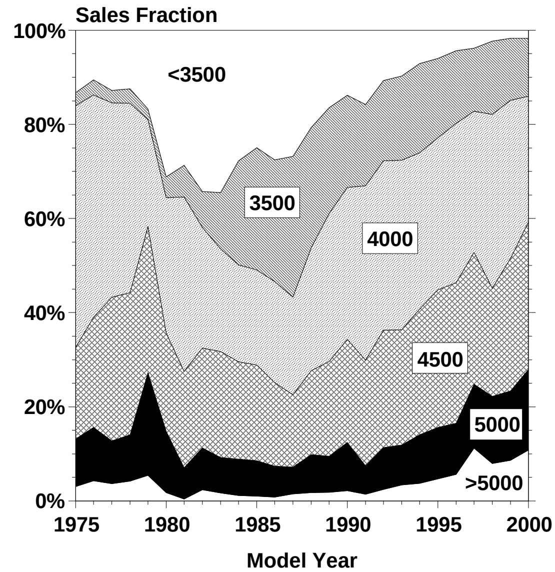

Figure 100

MPG vs Inertia Weight Class
Cars

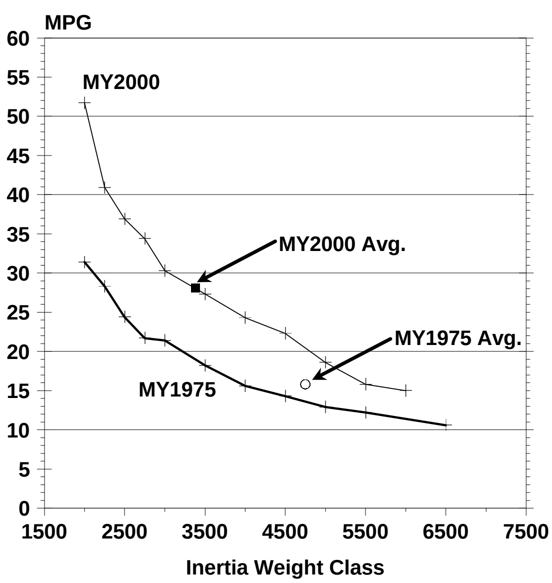

Figure 101

MPG vs Inertia Weight Class
Trucks

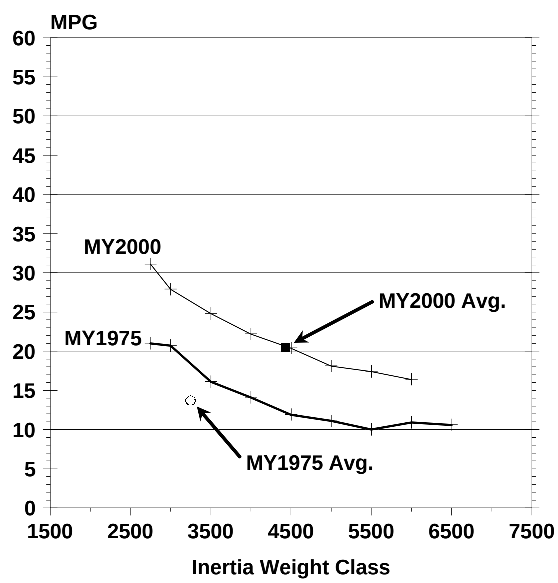

Figure 102

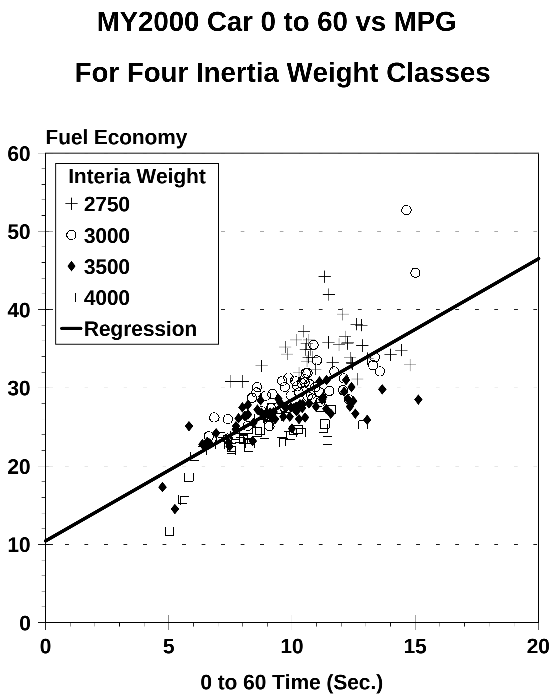

Figure 103

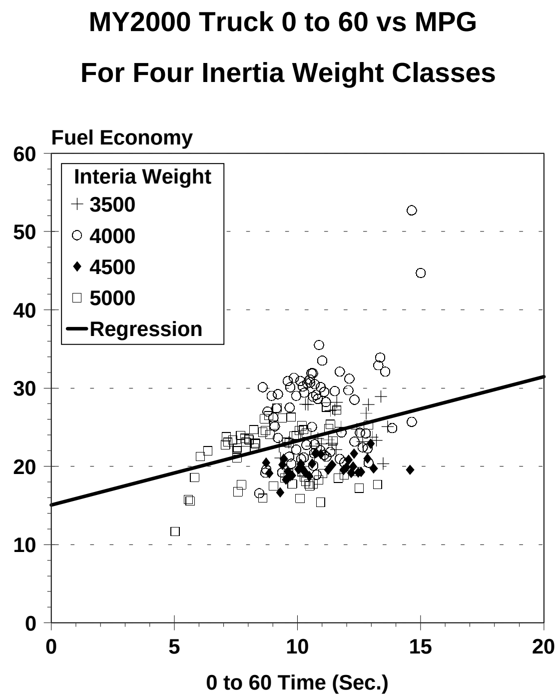

Figure 104

Figures 103 and 104 show the relationship between fuel economy and 0-to-60 acceleration time. Each data point in these two graphs represents an average mpg for cars and trucks in the same inertia weight class with the same 0-to-60 time. The mpg/performance interdependence was quantified by means of a regression analysis performed on the EPA databases as described in reference 20. This yielded sensitivity coefficients on the order of 0.4, i.e., a 10% increase in 0-to-60 time corresponds to a 4% increase in fuel economy. Using these sensitivities, average mpg data at one 0-to-60 level can be adjusted to what it would have at a different one.

Similarly, by normalizing either the weight or size distribution, a comparison can be made of what the fuel economy of each year’s fleet would have been if it had the same weight or size distribution as in a given base year. For comparison purposes, two base years were analyzed: 1981 and 1990. Table 21 shows that this year’s cars get better fuel economy than their counterparts from both baseline years but are significantly heavier and have faster 0-to-60 acceleration time. This year’s trucks get about the same fuel economy as the base line years and are also heavier and have faster 0-to-60 times.

Table 21 **Fuel Economy, Inertia Weight, and 0-to-60 Time For Three Model Years**

Vehicle Type	Model Year	55/45 MPG	Inertia Weight	0 to 60 Time
Cars	1981	25.1	3075	14.4
	1990	27.8	3175	12.1
	2000	28.1	3386	10.3
Trucks	1981	20.1	3805	14.6
	1990	20.7	4005	12.6
	2000	20.5	4432	11.0

Figures 105 to 108 and Tables L-5 and L-6 (Appendix L) provide estimates of what the mpg of the car and truck fleet would have been each model year if:

(1) the weight mix had been kept the same as in each of the two base years,

(2) the average acceleration time was kept at the base year's acceleration time, and

(3) both the weight distribution and average acceleration time were the same as in the base year.

A similar comparison on the basis of vehicle size and type is presented in Figures 109 to 112. For those cases (i.e., Small Vans and Large Wagons), values from the last year for which these vehicles were produced was substituted in the analysis as necessary.

Using model year 1981 as the baseline, and depending on whether tradeoffs are made on just weight, just vehicle size, or just acceleration performance, there is potential for improving the fuel economy of the model year 2000 combined car and truck fleet from 24.0 mpg to 24.2, 26.7 or 27.3 mpg, respectively, without introducing any new technologies. Similarly, again using model year 1981 as the baseline, had there not been tradeoffs in *both* weight and performance, model year 2000 cars might have averaged 34.8 mpg, trucks 26.0, and the combined fleet 30.1.

Effect of Weight and Acceleration on Car MPG

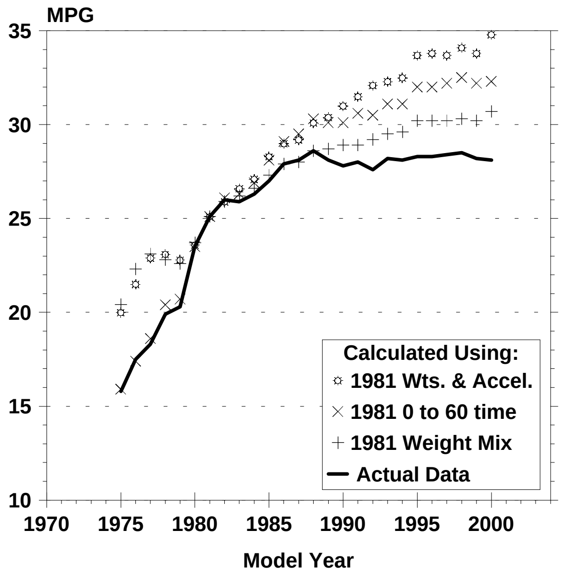

Figure 105

Effect of Weight and Acceleration on Car MPG

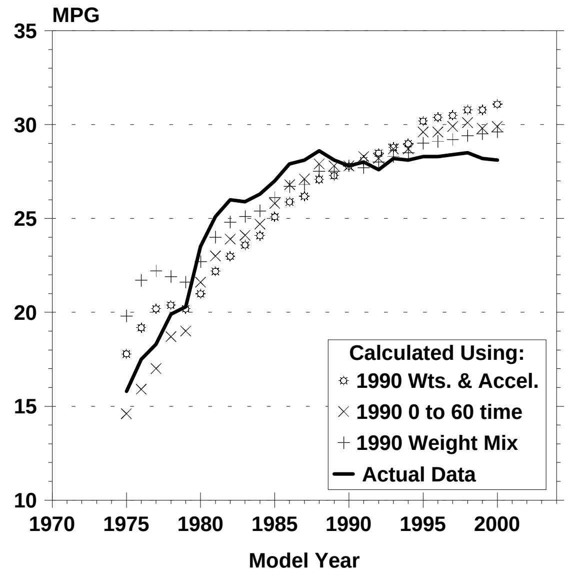

Figure 106

Effect of Weight and Acceleration on Truck MPG

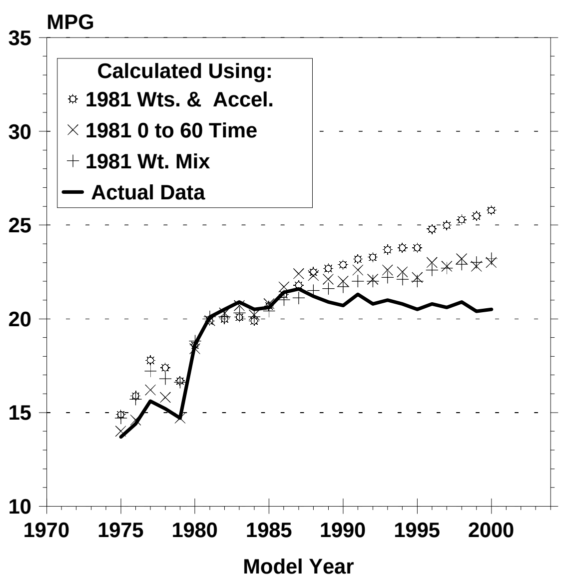

Figure 107

Effect of Weight and Acceleration on Truck MPG

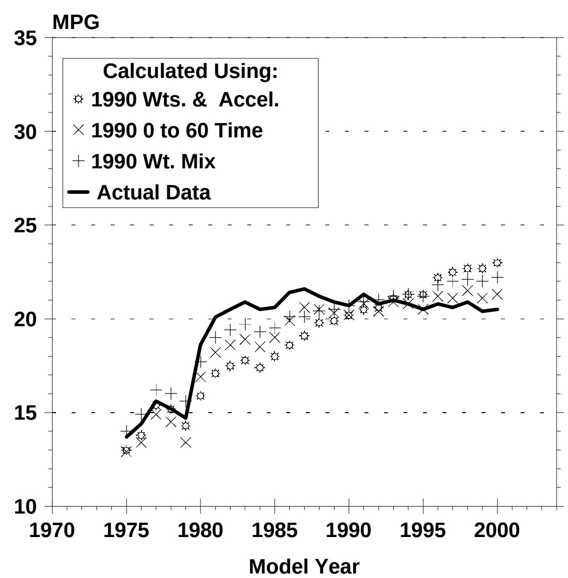

Figure 108

Effect of Vehicle Size, Type & Acceleration on Car MPG

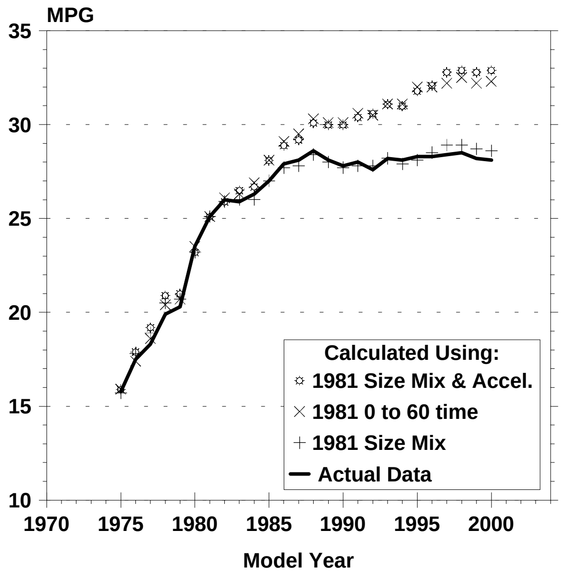

Figure 109

Effect of Vehicle Size, Type & Acceleration on Car MPG

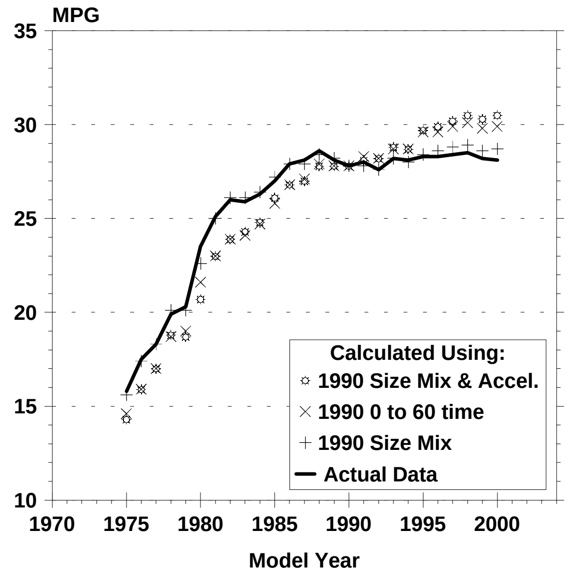

Figure 110

Effect of Vehicle Size, Type & Acceleration on Truck MPG

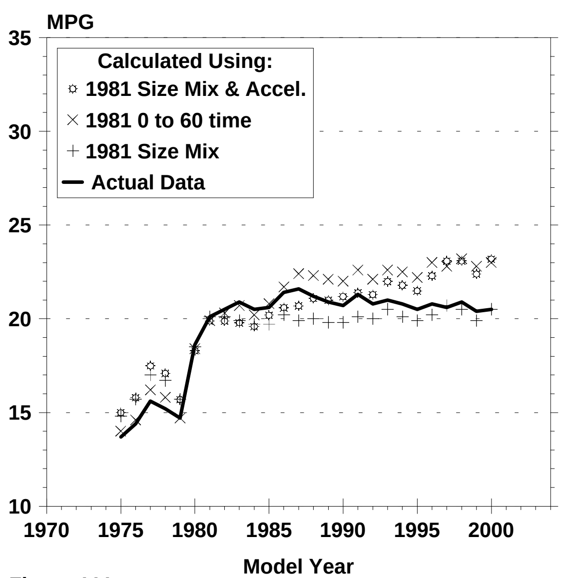

Figure 111

Effect of Vehicle Size, Type & Acceleration on Truck MPG

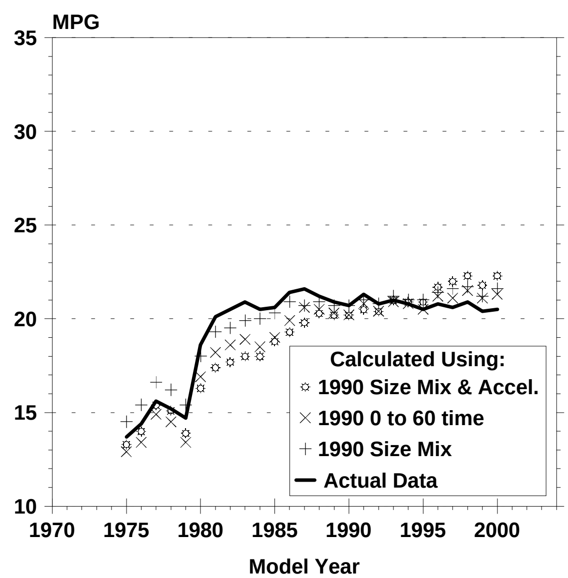

Figure 112

The fourth approach for projecting possible future fleetwide fuel economy improvement is to consider the use of a new, highly advanced, vehicle technology. The model year 2000 fleet contains one such vehicle, and it provides an indicator of even more substantial fuel economy improvement potential than any of the scenarios discussed above. The Honda Insight, which was introduced in model year 2000, is the first car on the U.S. market with a hybrid drivetrain which includes a gasoline-fueled engine, a battery that is used for traction, a regenerative braking system, and an electric motor/generator.

This manual transmission equipped two-seater achieves 76.3 mpg, compared to 25.2 mpg for the average non-hybrid vehicle in the two-seater size class. The Honda Insight, thus, is more than three times better in fuel economy than its conventional counterparts. Since the two-seater size class is not known for exemplary fuel economy, the same comparison can be made of the Insight to all small cars, which for MY2000 average 30.2 mpg. The Insight, by this comparison, is slightly more than 2.5 times more efficient than the average small car. The Insight, however, has a relatively light 2000 pound inertia weight. There is, moreover, only one other model year 2000 car with this inertia weight: a five speed manual transmission equipped Chevrolet Metro. The Insight achieves roughly 1.6 times the fuel economy of the Metro.

Based on a limited amount of fuel economy data, it appears that hybrid vehicles may have the potential to increase fuel economy *per vehicle* by at least 100%, and possibly as much as 200% over their conventional counterparts. It should be noted that it is a substantial technical challenge to attain such high fuel economy values for the entire fleet and, at the same time, retain all other vehicle performance and utility attributes at their present levels.

In addition, the potential for overall fleetwide fuel economy improvement due to hybrid vehicle technology is extremely dependent on their penetration rate. With a potential per vehicle improvement of 100 to 200%, hybrids could clearly provide a significant fleetwide fuel economy improvement, if and when they begin to penetrate the market significantly. Given there is only one hybrid vehicle now on the U.S. market, it is premature to postulate a fuel economy improvement scenario based on hybrid vehicles.

As shown in table 22, based on the scenarios discussed above, the potential for increasing combined car and truck fuel economy ranges from about 5% to about 25% with the lowest improvement coming from scenario 2 which involves a 25% fuel economy improvement in all SUVs. The highest improvements come from scenarios 3 and 5 which involve voluntarily improving fuel economy of all vehicles by 25% and using the 1981 weight mix and acceleration performance, respectively.

Table 22 **Summary of Fuel Economy Improvement Potential**

Scenario	Cars	Trucks	Both Cars and Trucks
(1) Actual MY2000 Averages	28.1	20.5	24.0
(2) 25% MPG Increase for All SUVs	28.1	22.5	25.2
(3) 25% MPG Increase for All Vehicles	35.1	25.6	30.0
(4) 1990 Weight Mix and Acceleration	31.1	23.0	26.8
(5) 1981 Weight Mix and Acceleration	34.8	26.0	30.1
(6) Best “Historic Year” Size Class	28.6	21.5	24.8
(7) Best 4 Nameplates in Size Class	31.4	21.6	26.0
(8) Best 12 Vehicles in Size Class	33.2	22.9	27.5
(9) Best 12 Vehicles in Weight Class	31.1	22.2	26.2

VII. Conclusions

1. Fuel economy of the overall light-duty fleet has declined 1.9 mpg (i.e., about 7%) since reaching a maximum of 25.9 mpg in 1987 and 1988, although during the past decade fuel economy of both cars and light-duty trucks, considered individually, has been relatively stable. This year's combined car and truck average value of 24.0 mpg is lower than it was at any time since 1980.

2. The share of the market comprised by light trucks has been increasing for over 20 years and now exceeds 46%, more than double what it was in 1983. Much of the decline in the overall light-duty fleet fuel economy is due to the sales fraction increase in light trucks. More than half of the light-truck sales fraction increase can be attributed directly to increases in the sales fractions of midsize vans and midsize SUVs.

3. Ton-mpg, for the combined fleet, as a measure of efficiency, has increased every year since 1979 and is now more than 33% higher than it was then.

4. On a model year basis, estimated lifetime light-truck fuel consumption has exceeded that of passenger cars for the past four years; for MY2000, light trucks are projected to consume 56% of the total.

5. Both cars and light trucks have traded off fuel economy for increased weight and performance. Since 1981, vehicle inertia weight for cars and trucks has increased by 10 and 16%, respectively. In addition, vehicle performance, as determined from estimated 0-to-60 acceleration time, has also improved. Had MY2000 cars and light trucks had an estimated 0-to-60 time of 14.4 seconds and the same weight as they did in 1981, they would have been able to attain over 25% better fuel economy.

6. Using a Best-in-Size-Class methodology and conventional vehicle technology, the combined passenger car and light-truck fleet has the potential to attain almost 15% better fuel economy.

7. New technologies used in hybrid vehicles, change the horizon for fuel economy projections and indicate improvements on the order of 100 to 200% may be possible. Recent developments suggest various potential pathways for possible future fleetwide fuel economy improvements including voluntary commitments by some manufacturers to improve the fuel economy of certain portions of their fleets by as much as 25%.

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